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The Delaware River Concrete Bridge, Slateford-Hopatcong Cut-off; Delaware, Lackawanna & Western R. R.

The new Slateford-Hopatcong Cut-off of the Delaware, Lackawanna & Western R. R., described in Engineering News, Aug. 13, 1908, p. 176, contains a great number of concrete structures, among which are two of the largest concrete bridges yet erected for any purpose, and the largest, so far as we know, for railway purposes. These two are both near the western end of the new work, one across the Delaware River near Portland, Pa., and the other over the Paulins Kill and its wide valley near Hainesburg, N. J. The former is some 1,450 ft. long and contains 51,500 cu. yds. of concrete, and the latter 1,100 ft. long, with 41,111 cu. yds. of concrete. The Connecticut Ave. bridge at Washington, D. C., heretofore the largest concrete bridge in this country, at least, is 1,341 ft. long and contains about 50,000 cu. yds. of concrete in mass and dressed block.

The Delaware River Bridge.

The new cut-off leaves the main line going east toward Hoboken at Slateford, Pa., about three miles east of Delaware Water Gap, and follows along the side of a hill practically on a tangent till it reaches a point about a mile west of the present station at Portland, Pa., where it turns on a 3° curve to the left and crosses the Delaware River on a skew of 25° to the river. The bridge, starting at the west end, consists of two 33-ft. arches, a 120-ft. arch, five 150 ft. arches and one 120-ft. arch, with the P. T. of the curve on the first 150-ft. arch, so that the two 33-ft. and the first 120-ft. arches are on larger skews than the remainder of the bridge, which is on a tangent. Its total length along the center line is 1,432 ft. and its width inside the parapets is 28 ft., carrying a two-track standard gage railway.

The river at this crossing has cut a gorge some 1,200 ft. wide, but in ordinary water only a small portion of this is flowing. However, it is subject to very sudden and high floods, which sometimes even now reach the limiting banks. The bridge, then, is for a considerable distance over ordinarily dry land and only the middle piers are being built in water. The two small arches at the west end are over a highway and the present tracks of the railway. From west to east the roadbed is on an up grade of 0.35%, which brings the crown of the intrados of the middle arch 51 ft. above mean high water and the ballast grade 63 ft. above the same elevation.

Design.

Each 150-ft. span is a solid arch of the semi-elliptical type carrying the roadway on transverse spandrel walls extending on the skew across the full width of the rib. Although originally designed with no reinforcement in the ring, it was thought advisable to include such reinforcement on account of the heavy service to which the bridge is to be subjected. Under the prescribed loading, however, the steel in the arch rings will not be stressed. This reinforcement, shown on the figures, consists of longitudinal lines of rods close to the extrados and intrados of the arch rib, joined by transverse but not by vertical rods.

The spandrels are vertical walls of rectangular section reinforced with vertical and horizontal transverse rods. At their top they are bracketed longitudinally to carry a 1 ft.-9 in. reinforced-concrete slab directly on which the ballasted roadway is laid. For appearances, the spandrels are connected at the faces of the arch by showing arches which are only 3 ft. thick. The roadway is guarded by heavy concrete parapets bearing a pipe railing between concrete balusters.

The drainage from the roadway is carried to each pier and through it to the ground in the usual manner, but a novelty has been added in the drains cut into the extrados of the main arch and through the spandrel walls just inside the face, which are to care for any water that gets through the floor or driving rains blown between spandrel walls onto the top side of the arch barrel and thence might drain off the showing faces to their disfigurement.

No expansion joints are provided from one end of the structure to the other. The spandrel walls are not completed until after the arch centers have been struck, and then the floor slab is placed from abutment to abutment as a continuous beam.

The two 33-ft. arches are on about 50° skews so that their pier transverse length is 62.5 ft. for a bridge width of only 34 ft. Each of these arches is of the solid barrel type, 30 ins. deep at the crown, and reinforced at extrados and intrados lines with 1-in. bars 12 ins. c. to c., joined by transverse ½-in. bars spaced 2 ft. c. to c., but with no vertical connecting bars. Instead of the transverse spandrel walls of the larger arches, the small spans have solid parapet walls filled in between with earth.

The 120-ft. arches are similar in design to the 150-ft. spans described and illustrated, except for the change in dimensions. The crown thickness of the 120-ft. arches is 5 ft. 4 ins.

PIERS.—The piers are of solid concrete up to the extrados of the arch, above which point they are of the hollow wall construction shown in Fig. 3. In all cases they extend down to solid rock, which is about the same elevation all the way along the line of the bridge, but the difference in ground level makes the total vertical length of the piers differ greatly. There is an excavation of 61 ft. at Pier No. 1 and only of 24 ft. at Pier No. 5 at the east shore of the river. All of the piers are greatly enlarged below the ground level.

Two of the piers are in the nature of partial abutments, and as such have a slightly different construction in the lower portion. One of these, Pier No. 2, is a natural abutment pier, on account of the unbalanced thrust coming from the larger arches on the east. Pier No. 5 is at the end of the last 150-ft. arch to be constructed during the present season, and so must take the unbalanced thrust from the arches to the east of it all during the coming winter. On this account the base has been greatly enlarged and reinforced (Fig. 2), so as to preserve the stability of the pier.

The skewed position of the bridge made the connection of the barrel of the arch to the pier rather a complicated problem. How it has been solved is best illustrated by Figs. 6 and 7, which show Piers 2 and 3. In each case the skewback has been divided into six sections, with faces each normal to the line of the arch thrust, but in the abutment pier the skewback itself has been stepped off to give a more effective bond.

ABUTMENTS.—The two abutments are of the U-shaped type, with sloped and stepped reinforced walls filled in between with earth. The west abutment takes only the thrust from the

VIEW TAKEN OCT. 1909, OF THE DELAWARE RIVER BRIDGE ON THE HOPATCONG CUT-OFF OF THE DELAWARE, LACKAWANNA AND WESTERN R. R.

(Looking up the Delaware River toward the Delaware Water Gap in the distance. East end of bridge on the right.)

two 33-ft. arches and is also on high ground so that it is comparatively simple in construction. The east abutment takes the thrust from the series of 150-ft. arches and is, in addition, on low ground, so that it is very massive. This is shown in Figs. 4 and 5. It is 60 ft. long, 42 ft. wide at the widest point and 62 ft. high above ground

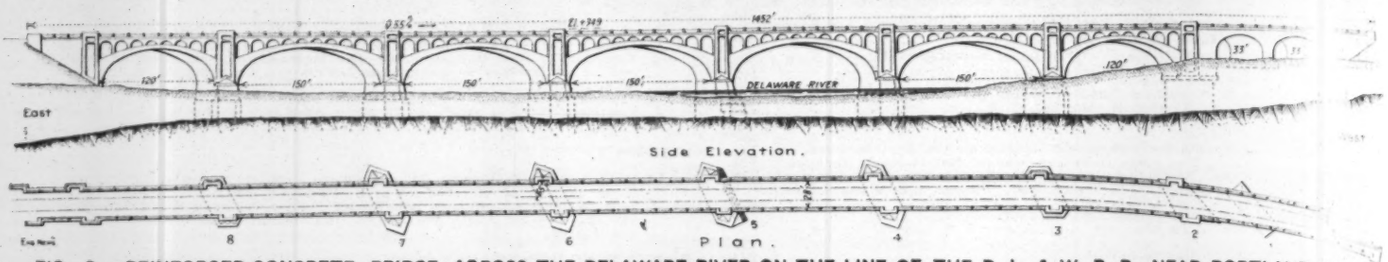


FIG. 2. REINFORCED-CONCRETE BRIDGE ACROSS THE DELAWARE RIVER ON THE LINE OF THE D. L. & W. R. R., NEAR PORTLAND, PA.

level. The toe of the abutment, where the thrust from the arches is cared for, has its footing reaching down to solid rock, some 50 ft. below the springing line, but the base of the walls is 46 ft. higher on gravel. A noteworthy feature of the design is the series of heavy reinforced-concrete beams tying together the two side walls. These are at the level of the top of the steps at the lower part of the walls, and are tied thereto with the extension of their own reinforcement.

Steel Arch Centering.

One of the leading features of the Delaware River Bridge is the use of steel arch centers. For the two 33-ft. arches and for the 120-ft. arches the usual timber centering, founded on sills and piles, was employed, but for the five 150-ft. arches a special centering was built of steel arch ribs, supported only at the ends on the bridge piers and controlled in its vertical movement entirely through one transverse set of screws. Two sets of this centering were built to be used successively on the five arches. The details of construction and a view during concrete laying are shown in Figs. 8-11.

The centering for one arch is composed of 10 steel hinged arch ribs, spaced equally along the skewed piers and joined together by lateral systems into a rigid framework. On top of this framework is laid the timber lagging against which the concrete arch rib is placed. The members are of the sections shown in Fig. 8, riveted at all but the hinge connections, which constitute the main point of distinction between the centering and any spandrel braced arch rib. Lateral bracing consists of a diaphragm connecting the lowest extrados verticals and of transverse angles at the upper and lower panel points, and one line of sway bracing at the haunch panel points. The outer two ribs are connected by diagonal laterals in addition.

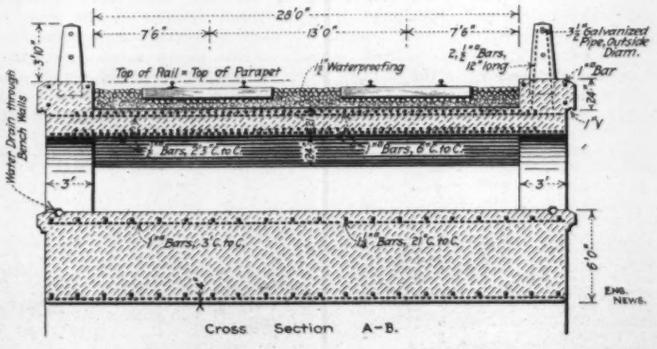
The spring hinge is shown in Fig. 11. The piers on each end of the arch are first built up to the skewback (Fig. 8) leaving projecting under the arch barrel a step in the footing course at the ground elevation of the pier extending for the whole width, and a corbel about six feet higher, a block in line with each of the ten centering arches. On this lower projection (Fig. 11) is placed a four I-beam grillage extending the whole width of each pier, and upon it at proper intervals, are placed the short built-up columns, which act as the reaction bases for the centers. At the top of each of these short columns is the springing hinge of the arch, the ordinary pin joint, but to take the horizontal component of the thrust, the top of the column is blocked with a timber piece against the corbel on the concrete pier. Thus the thrust from the loaded centers is carried directly down and into the bridge piers. When the centering is removed the projecting corbels are chiseled off and the surface made plane, but the lower curb or ledge, being at the ground elevation, is allowed to remain.

The crown hinge is shown in Fig. 9. This is not only a hinge for the arch, but also a lifting and lowering device by means of which the arch centers may be struck. The trapezoid of members around the center pin is a double toggle joint, with an extension member on each side, the movement of which raises or lowers the crown pin and thus the whole arch centering. The details of this extension member are also shown in Fig. 10. It consists of a built-up column carrying in its middle a double ended screw, controlled by a lever. By turning the lever the member is lengthened or shortened. If lengthened the crown pin of the arch center drops, if shortened the crown pin rises.

By this center joint the whole centering can be controlled. Thus all of the ten ribs are first erected in place, then by means of the toggle they are all moved until in correct alinement. Then the sway and lateral bracing is bolted onto the gussets, the lagging placed and the concrete laid. When the time for striking has come the bracing is unbolted and removed, a man is stationed at each of the 20 levers at the toggle and simultaneously the whole crown of the centering is dropped and the concrete arch takes its own load. The centering can now be dismantled and moved to the next arch. This process has been followed with great success on the three arches so far erected.

In designing the steel centering, it was assumed that the dead load from the wet concrete came directly down upon the various panel points; no initial arch action due to the settling of the concrete was considered. In addition it was assumed that once the concrete had set it would not be as susceptible to temperature change as would the steel, so that the expanding steel arch acting against the rigid, or almost rigid, concrete rib during a rise in temperature would induce extra stresses in the steel members. For the first of these stresses in the steel, viz., that due to concrete load alone, the usual safe stresses of 16,000 lbs. per sq. in. in tension and 17,000 lbs. per sq. in. in compression were allowed, but for the temperature stresses the elastic limit of the material was taken as the limiting safe stress, partly on account of the improbability of the occurrences of the maximum temperature stress and partly because of the temporary nature of the steel construction.

Under an assumption of 150 lbs. per cu. ft. for the arch ring concrete, the deflections computed were as follows: Temperature change of 140° F. = 17/32-in.; under own load and dead



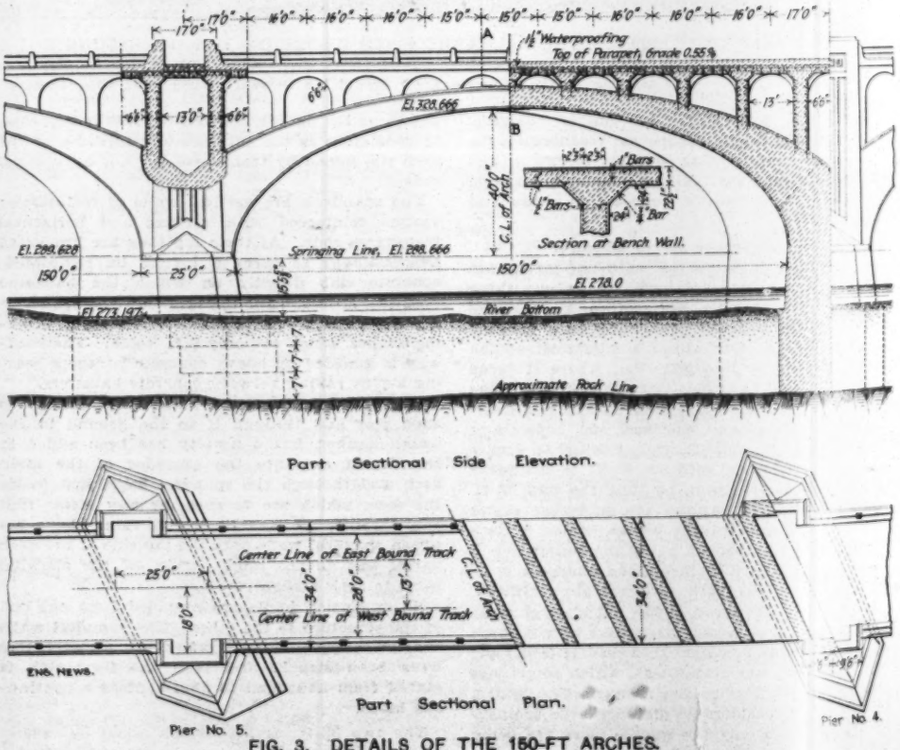


FIG. 3. DETAILS OF THE 150-FT ARCHES.

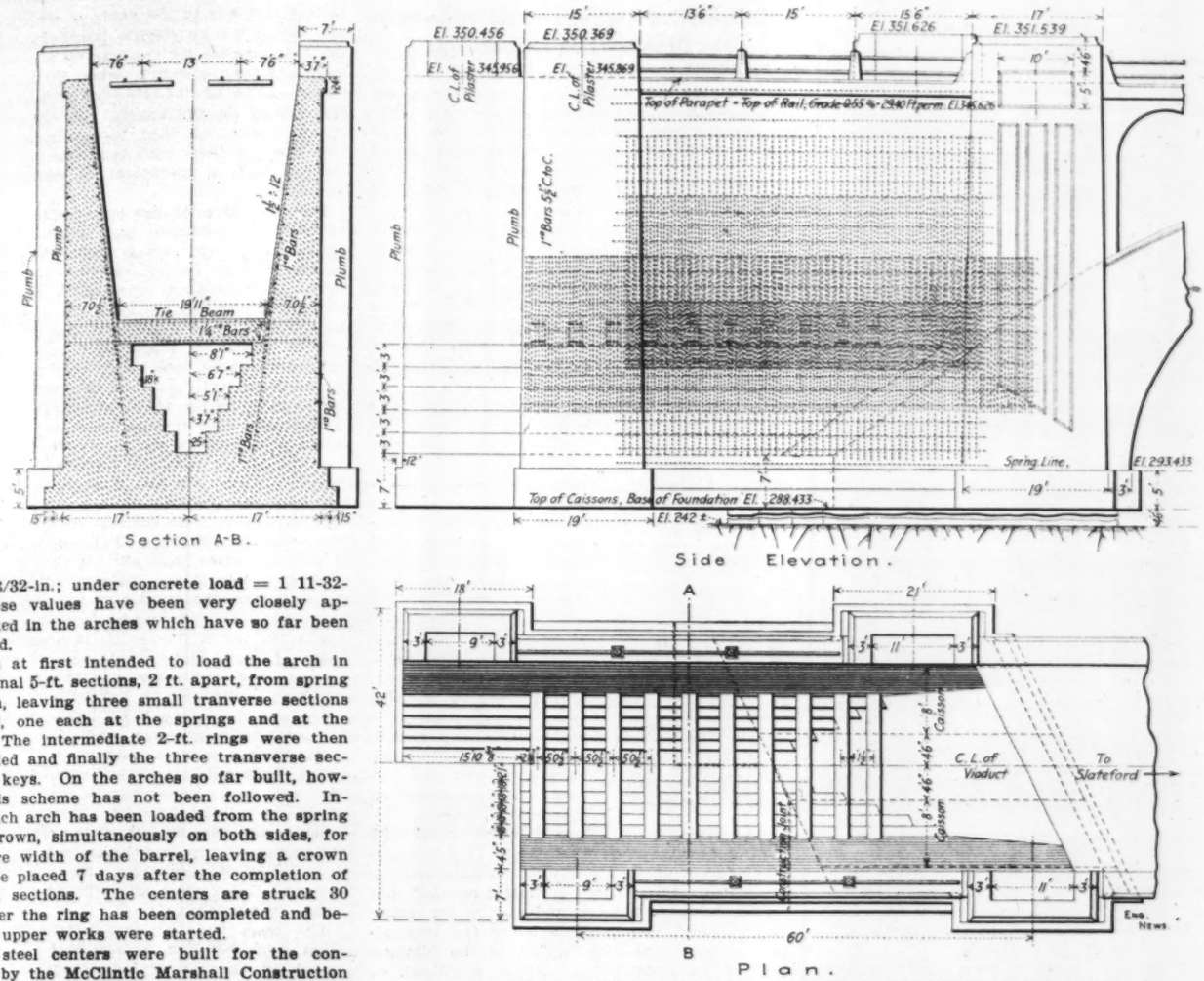

Section A-B.
Side Elevation.
Plan.
Top of Parapet = Top of Rail. Grade 0.55% = 2.40 Ft. perm. El. 346.626
Top of Caissons, Base of Foundation El. 288.433
Spring Line, El. 293.433
C.L. of Viaduct
To Slateford
Eng. News

FIG. 4. DETAILS OF EAST ABUTMENT, DELAWARE RIVER BRIDGE.

load = 3/32-in.; under concrete load = 1 11-32-in. These values have been very closely approximated in the arches which have so far been completed.

It was at first intended to load the arch in longitudinal 5-ft. sections, 2 ft. apart, from spring to crown, leaving three small tranverse sections unloaded, one each at the springs and at the crown. The intermediate 2-ft. rings were then to be filled and finally the three transverse sections as keys. On the arches so far built, however, this scheme has not been followed. Instead, each arch has been loaded from the spring to the crown, simultaneously on both sides, for the entire width of the barrel, leaving a crown key to be placed 7 days after the completion of the first sections. The centers are struck 30 days after the ring has been completed and before the upper works were started.

These steel centers were built for the contractors by the McClintic Marshall Construction Co., Pittsburg, Pa., and were designed and built under the direction of Mr. Paul L. Wolfel, M. Am. Soc. C. E., Chief Engineer, and Mr. David S. Gendell, Jr., Engineer of Construction, of that company. Under the terms of the contract the McClintic, Marshall Co. designed, built and superintended the erection and removal of the centering, the latter under the direction of the contractors for the bridge.

The 120-ft. arches were cast with three keys, two at the ⅓ points on either side of the crown and one at the crown in which a final key was poured. These keys were in jogged form so that there were six openings each normal to the longitudinal axis of the arch. This was required on account of the skew; if one tranverse opening had been left, the surface between the new and old concrete at the key would not have been normal to the line of thrust and therefore might some time be a plane of weakness.

Architectural Details.

Although the bridge is well out in the country, a considerable distance away from any large settlement, the designers have given it some artistic merit. The lines are graceful and the decorations to the pier, though simple, are very effective. In appearance it will compare favorably with some more pretentious bridges. Wherever a pier comes in contact with water the surface has been bush-hammered, elsewhere it has been rubbed. On the cut-waters and edges of the river piers granite quoins have been placed, set in smooth with the concrete surface. On the arch ribs, the exterior lagging has been placed in radial lines so that whatever lines show on the rubbed surface will be normal to the intrados of the rib.

Construction.

The erection is controlled from a traveling cableway divided into two units by an A-frame tower in the middle of the bridge, just east of pier No. 5. This tower is founded on a high pyramidal block of concrete, which is to be removed when construction is completed. On either side of the river is a concrete mixing plant, each supplying its half of the work so that con-

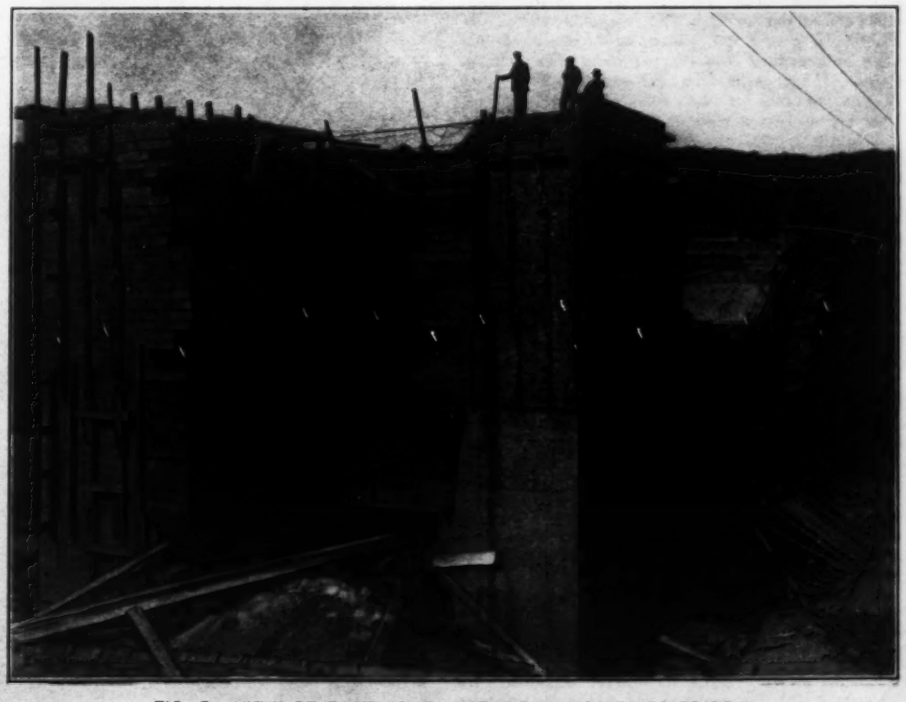


FIG. 5. VIEW OF EAST ABUTMENT, DELAWARE RIVER BRIDGE.

crete laying can go on at either side of the river at one time. Even with the longest haul from shore to the mid-river pier each mixing plant has a capacity of about 250 cu. yds. in a 10-hour day. Crushed stone is obtained from a quarry only about one mile distant on the Pennsylvania side, but sand and cement has to be shipped in via railway. For the copings and ornamental details a 1:2:4 mixture is being used; for the foundations and the piers below springing line of arches, a 1:3:5 with large embedded stone; for the remainder of the structure a 1:3:5 concrete without the large stones.

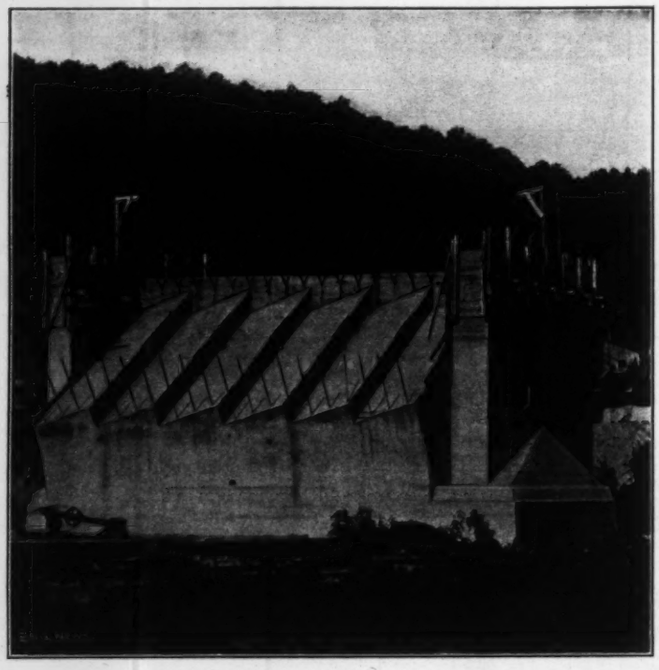


FIG. 6. VIEW OF PIER NO. 3 UNDER CONSTRUCTION.

During the first season's work, which is now completed, all the piers and both abutments have been built and the two 33-ft. arches, and the 120-ft. arch on the west side sprung. On the east side, the 120-ft. arch was first built, on timber falsework, afterward moved over to the west 120-ft. arch, then the first three 150-ft. arch ribs completed level. The season's work has stopped at Pier No. 5, which, as noted above, has been enlarged to care for the unbalanced thrust from the arches on the east side. During next season the rest of the work, that is, the two westerly 150-ft. arches and the upper works of the whole bridge, will be finished.

The bridge was designed under the direction of Mr. L. Bush, M. Am. Soc C. E., up to a short time ago Chief Engineer of the railroad, and of Mr. G. J. Ray, M. Am. Soc. C. E., at present Chief Engineer. They were designed in the office of Mr. B. H. Davis, Assoc. M. Am. Soc. C. E., Assistant Engineer, and are being built under the direction of Mr. F. L. Wheaton, Engineer of Construction. The contractors for this division of the cut-off are Messrs. Smith & McCormick, of Easton, Pa., and they are giving their personal attention to the construction of the bridge.

We have to thank the engineering department of the railroad for the photographs used here and for the drawings of the bridge proper. The McClintic-Marshall Co. kindly furnished us the details of the steel centering.

THE POPULATION SCHEDULE for the Thirteenth Census of the United States has been formulated and has received the approval of Mr. E. Dana Durand, Director of the Census. It contains 32 questions, answers to which are to be gathered for every man, woman and child in the country. The census for 1910 will be taken as of April 15, or a month and a half earlier than heretofore. The object of this moving forward of date, we presume, is to catch the considerable element of the city population before it begins its summer migration. We understand that the population and agriculture schedules will be completed before the manufacturing and other schedules are taken up, as was the case in 1900.

A Comparative Test of Electric and Acetylene Headlights on Locomotives.

By HENRY L. GRAY,* Assoc. M. Am. Soc. C. E.

During the recent session of the legislature of the State of Washington, the Railroad Commission law was amended to provide that locomotives used on passenger trains (except those assigned to strictly daylight runs) should be equipped with electric headlights of approved design and power before Sept. 1, 1909, and that all locomotives in main line service, should be so equipped before Feb. 1, 1911. Also, that it should be unlawful to operate locomotives not so equipped unless permitted to do so by the Railroad Commission. The enginemen of the state were instrumental in having the above law passed, the railways opposing it, as they have opposed similar legislation in other states.

Shortly after the law was enacted, the Great Northern Ry. petitioned the Railroad Commission to exempt certain runs; it requested a hearing, and an opportunity to demonstrate the general undesirability of electric headlights and the superior advantages of acetylene. Expert witnesses were called and examined, the conclusions arrived at in other states being carefully considered. The railway officials contended that electric headlights were undesirable for many reasons, chief among them being the impossibility of distinguishing signals in the blinding glare of an approaching electric headlight, or the classification signals on a locomotive carrying an electric headlight. It was claimed also (1) that such lights were a menace to double track operation and yard work; (2) that a locomotive standing in the yards or station grounds, and displaying an electric headlight, would render it impossible for the man on an approaching engine to see the switch lights; (3) that the continued glare of the electric headlight affected the eyes of the enginemen. On the other hand, it was contended that the acetylene headlight had none of these bad qualities, and was preferable from a standpoint of economy, utility and safety.

The advocates of the law denied the danger of electric headlights, and contended (1) that on a single track, signals could be distinguished as far with an electric light as with any other light; (2) that at a considerable distance from an approaching electric headlight, it was possible to stand in such a position that the head end of the locomotive would shut out the glare of the approaching light, and signals might then be distinguished; (3) that locomotives standing on passing tracks were required to hood their lights, and that it was unnecessary to distinguish the markers on an engine on a second track; and (4) that the electric headlight converted a night trip into a daylight run, rendering it unnecessary to observe the switch lights, as the targets were plainly discernible. As to the acetylene headlight, they contended (1) that it was no better than oil; (2) that it was dangerous, owing to the liability of escaping gas igniting from the torches of the enginemen; (3) that in winter, the water in the pipes of the apparatus would freeze; (4) in a snowstorm the glass of an oil light would become frosted and obscure the light, while winter weather had no effect on an electric light; (5) that the glare of an electric light had no detrimental effect on the eyes of enginemen, and that electric cab lights were a great advantage.

The Railroad Commission was of the opinion that the most serious charge made against the electric headlight was its tendency to obscure signals, and the officials of the Great Northern Ry. volunteered to furnish the equipment and conduct practical road tests, the members of the Railroad Commission and officials of other railroads to participate.

The tests were conducted over 30 miles of main track between Everett and Gold Bar, selected on account of long tangents. Electric headlights were used the first night, and acetylene headlights the night following. The party numbered 15 in all, including four representatives of the Railroad Commission. The railway representatives were composed chiefly of enginemen and operating officials, and included

*Engineer, Railroad Commission of Washington, Olympia, Wash.

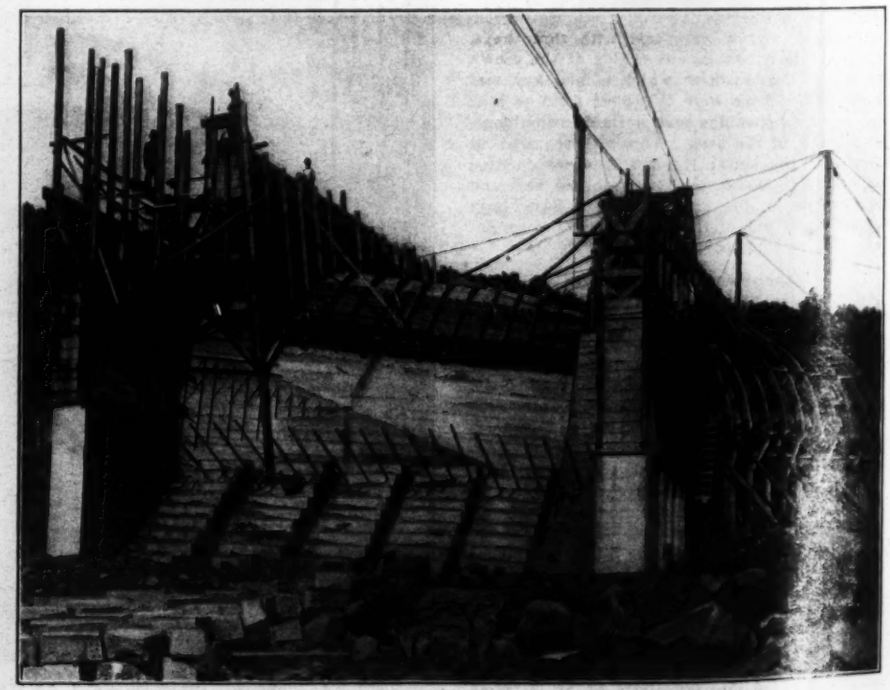


FIG. 7. VIEW OF EAST SKEWBACK OF PIER NO. 2.

...ne member of the legal department, who had ... experience in train operation.

The party was assembled in a car, over the ... of which a platform had been constructed, ...d upon which was a Pyle electric headlight* ...ated at 1,200 c.p., placed slightly higher than ... would be when attached to a locomotive. The opposing headlight, and at a distance of 3,000 ft., were total failures, as none of the party observed any of the signals. These two tests should not be considered, and are not included in the tabulation of the results.

Of the five colors, red and white were the most easily distinguished, and tied for first place.

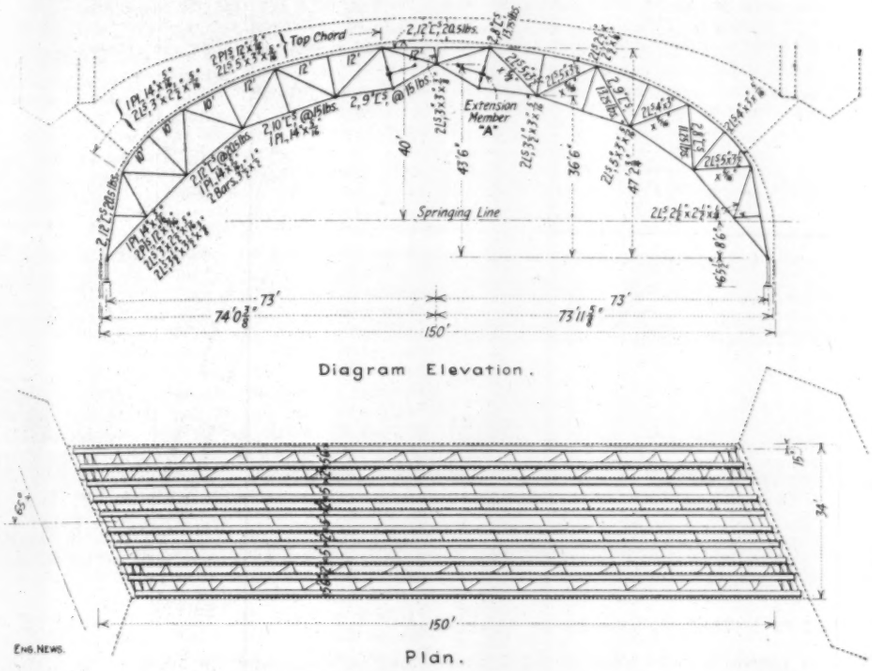


FIG. 8. STEEL CENTERING FOR 150-FT. ARCHES, DELAWARE RIVER BRIDGE.

car was pushed by an engine with a blind headlight. The tests were designated as single track and double-track tests, the effect of meeting an electric headlight on a second track being obtained by placing several locomotives on passing tracks along the route, with opposing headlights. In the single-track tests only the light mounted on the car was used.

Six signalmen were placed at various intervals along the route, each having five lights (red, yellow, green, blue and white) carried in a covered box, and having instructions as to the order in which they should display them. The enginemen on the locomotive attached to the car were informed as to the location of the signals. When within about 3,000 ft. of a signalman, and approaching at a speed of eight miles an hour, the whistle would be blown. The lights would then be displayed, the signalman taking each in turn from the box and holding it about the height of his head for ten seconds, then returning it to the box. The lights were all exposed at distances varying from 1,500 to 3,000 ft., the majority of them being about 2,400 ft. distant. In the double-track tests, the signals were all displayed directly in front of the opposing headlight, and only about 600 ft. from it.

The observers were furnished with cards, providing blank spaces for the name of the observer, number of trip, signalman's number, and color of signals. As the signalman displayed his lights, the observers would mark down the colors noted in their order. Upon the completion of the trip, the signalmen turned in their cards showing the order of signals, and comparisons were made. The acetylene gas tests were conducted in the same manner with the Rushmore acetylene headlight.† Six double-track, and six single-track tests were made with the electric headlights, and eight double-track, and four single-track tests were made with acetylene. The observers were for the most part ig...orant of the position of the signalmen and co...r of lights, but were informed as to the le...th of time they were to be displayed. The first two electric tests, made in the face of an Yellow came third; green, fourth, and blue a poor fifth. On the double-track acetylene tests, however, yellow rose to second place, while white dropped to third; either red or white occupied first and second place. The poor showing of green was a disappointment to many members of the party. The order in which the lights were displayed had a marked effect on the general average. If the same color was displayed twice by the same signalman, it might attain a high average on the first exposure, but was almost sure to average low on the second, as the observers would naturally expect a different color, and would use their imagination freely in naming the second light.

There was a general inclination to call yellow, red, and in one instance to call green, white. The fact that colors were misnamed was to some extent due to the system of recording observations. For instance, light No. 1 might have been green, but should the observer fail to see it, he would mark the color of light No. 2 (which may have been red) in the space reserved for No. 1, thus recording incorrectly a light which he had correctly named. A large percentage of the errors were clean misses. The accompanying table (summarised from the tabulations of the individual tests, Ed.) shows the result of the tests.

TABLE OF OBSERVATIONS OF COLORED LIGHTS EXPOSED IN THE FIELD OF ELECTRIC AND ACETYLENE HEADLIGHTS.

	Correct.	Missed.	Incorrect.
Red	14	1	0
Green (1st)	11	1	3 (2 blue, 1 yellow)
Yellow	12	2	1 (1 red)
Blue	12	2	1 (1 green)
Green (2d)	1	4	10 (10 white)

	Percentage of Correct Observations.			
	Single-Track Tests.		Double-Track Tests.	
	Electric.	Acetylene.	Electric.	Acetylene.
Red	96.6	90.8	51.7	89.4
Yellow	67.6	78.4	24.4	87.5
Green	50.8	72.6	8.9	60.8
Blue	30.7	28.6	8.3	23.2
White	93.6	93.9	45.3	76.8
Gen. av.	64.3	72.6	37.0	67.6

It is interesting to note that the observer who held the record for correctness in both the electric and acetylene tests, was a representative of the legal department, unfamiliar with train operation, and who (according to his own confession) had never before seen a yellow or blue light displayed on a track.

While the tests were conducted with great impartiality by the railway officials, they were in a measure unfair, particularly to electric headlights. During at least six of the electric tests, the lights were improperly focused, while the rays of the electric light mounted on the car always formed a sharper angle with the vertical than those of the opposing headlight. The latter could be seen for several miles, and as the speed of the train was slow, the party was obliged to gaze into the rays of the oppos-

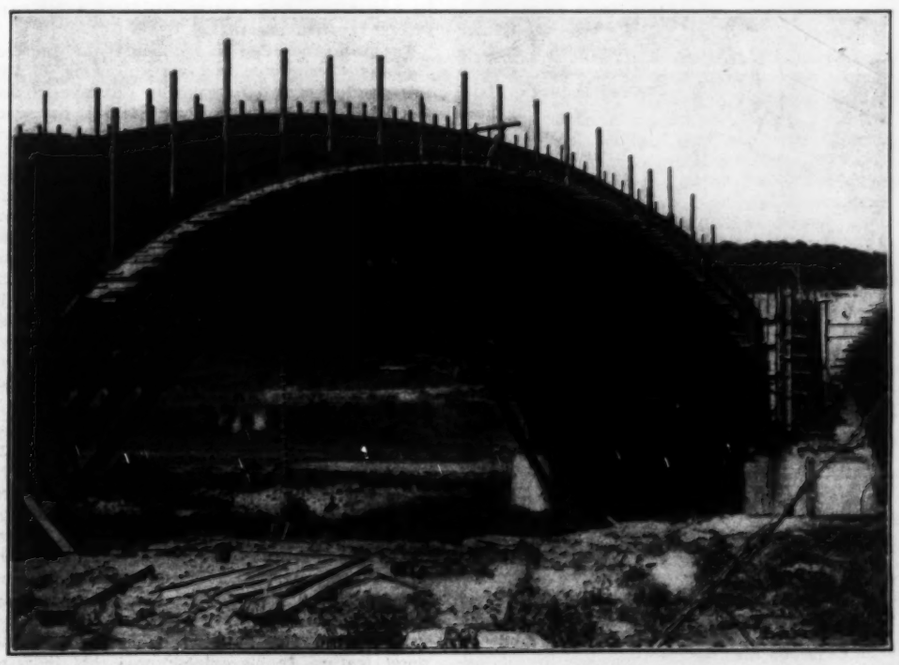


FIG. 9. VIEW OF STEEL CENTERING UNDER 150-FT. ARCH.

ing light for a considerable time before the signals were displayed. Had the observers been stationed in the cab of a locomotive, the headend would have shut out the glare for a large portion of the time.

The observers were, to a large extent, unfamiliar with conditions under which the sig-

*Engineering News, June 16, 1898.
†Engineering News, July 24, 1902.

nals were to be displayed, while engine and trainmen are not permitted to work on regular runs until they are well acquainted with the location and character of signals. The signals approximated switch lights only, as they were too low for semaphore signals, and were held practically motionless. The distance at which the signals were displayed was too great, and they were not displayed long enough. The engineman of a train running 60 miles an hour, noticing a light 2,500 ft. distant, would have 20 secs. to determine its color before he began to slow down, whereas, the observers were allowed only ten seconds. In the case of double-track operation, track signals are always placed on the right-hand side, and out of the glare of an opposing light, and it is very improbable that hand signals would be displayed motionless directly in front of an electric headlight.

At the request of the Railroad Commission, certain supplemental tests were made, from which it was determined that both a man on the track, and a switch target, could be seen a distance of approximately 1,200 ft. with the electric headlight, and 600 ft. with acetylene. An open switch was observed 180 ft. with the former and 90 ft. with the latter. There was no apparent difference in the distance a red or green light could be seen with either headlight, and the light could be seen as well, but no better, with a blind headlight.

The conclusions reached by the Railroad Commission are conveyed in the following paragraph from the answer to the petition.

Conceding the discretionary power to be sufficiently broad as to authorize the Commission to suspend the operation of the law and permit the substitution of acetylene for that provided for in the act, it should be exercised in cases only where the Commission is clearly satisfied that the light substituted is superior to that provided for. It is not sufficient that the light sought to be substituted is equally as good. To hold otherwise, would authorize the Commission to annul the legislation because it might disagree with the legislative judgment on questions of policy and expediency. While such might be said as to the efficiency of the acetylene light, it is sufficient in dealing with this petition to say that the demonstration does not convince us that the acetylene light is superior to the electric light to such an extent as would justify us in suspending the operation of the law. Petition denied.

In connection with the above, it is of interest to note that in both Georgia and North Carolina laws were passed in 1909 making the use of electric headlights compulsory, and the former law specifies a 23-in. reflector. A similar law was passed by the legislature of Missouri this year, but was vetoed by the governor in view of an agreement arrived at between the railway employees (who had backed the bill) and the railway companies (which had opposed it). As a result of tests made under the direction of both parties, an agreement was made between them by which the railways agreed to equip their locomotives in main line service with headlights of sufficient power to make a man on or beside the track clearly visible at a distance of 800 ft. from the engine.

The same question came before the Indiana Railway Commission last spring, owing to the introduction of a bill requiring railways to use electric headlights. In place of this, however, an act was passed empowering the Railway Commission to investigate the matter. At a conference held in May (Engineering News, June 10, 1909), there was a consensus of opinion unfavorable to the electric headlight, not only on the part of officials of the railway mechanical departments, but also on the part of enginemen who gave evidence. The arguments are said to have been a surprise to the commission, and it was decided that practical tests should be made. We are informed by the secretary of the commission that the investigation has not been concluded, and that no particulars can be given at this time.

In a paper read before the Western Railway Club (Engineering News, May 19, 1909), Mr. J. A. Carney, Master Mechanic of the Chicago, Burlington & Quincy Ry., reviewed the advantages and disadvantages of the electric headlight. In the first place, he said that as a warning to the public at grade crossings "its value is almost without estimate." On the other hand, he considered that it was a nuisance in a switching yard, "as it almost obliterates hand lanterns and switch lights that come in its field." But its worst feature, in his opinion, was that in rain, snow or mist (not heavy enough to obscure signal lights), the rays of the electric lamp light up the particles of moisture in such a way as to produce a curtain of light through which it is almost impossible to see signals at a safe distance. He thought the light could be improved by placing a cylindrical hood or extension on the lantern to concentrate the rays into a smaller pencil of light.—[Ed.]

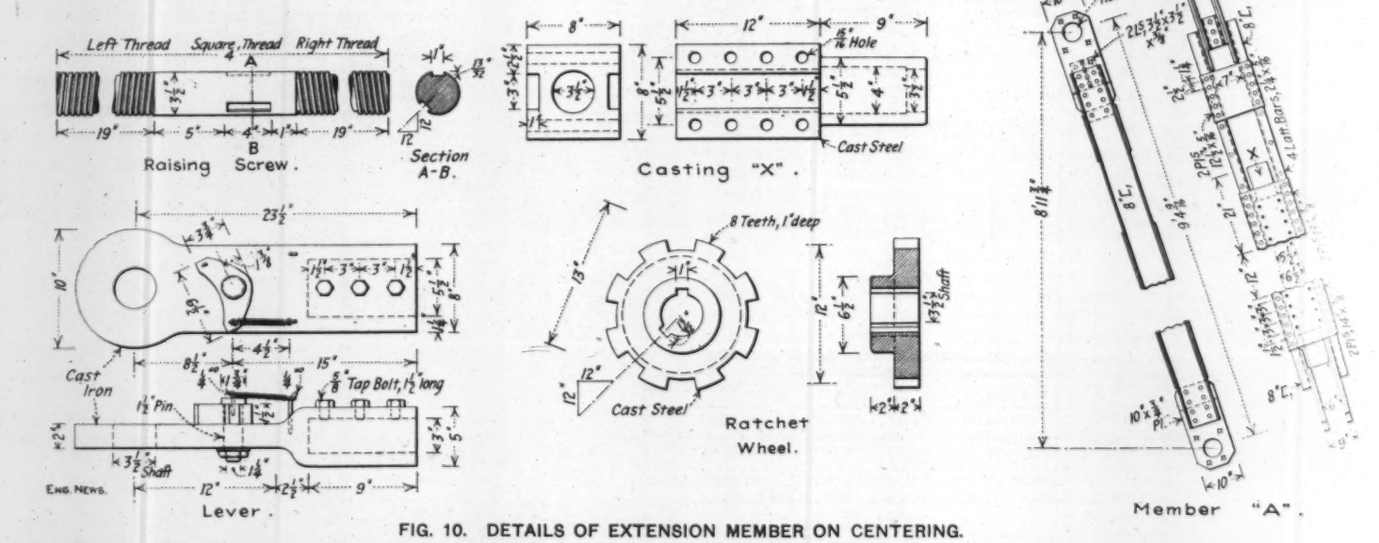


FIG. 10. DETAILS OF EXTENSION MEMBER ON CENTERING.

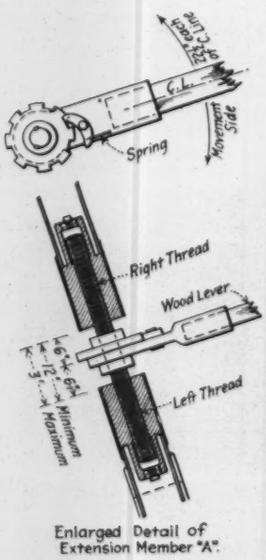


Fig. 11. Assembled Details of Extension Member "A" of Fig. 8.

French Government Regulations for Work Under Compressed Air.

Under a recent decree the French Government has issued a new set of regulations governing the operation of all works under compressed air carried on in the republic. These rules are a revision of a set that for some time has been in force in France, and represent the latest ideas in that country regarding the proper administration of compressed air work so as to insure safety to the workmen. In the "Annales des Ponts et Chaussees," Sept.-Oct., 1909, there is a complete transcription of the regulations, and from that issue we have abstracted the portions that will probably be of interest to American compressed air workers. These portions are given below.

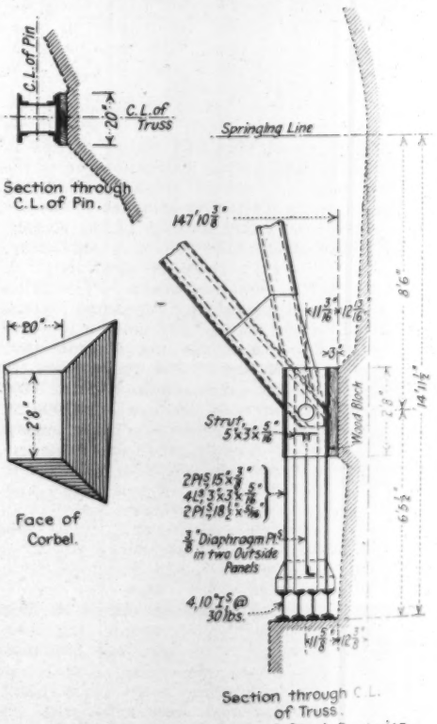


Fig. 12. Details of Base of Steel Centering.

Regulations for Compressed Air Work.

A doctor, appointed by the chief engineer, shall be in charge of the medical service. No workman shall be admitted into a compressed air caisson until he has been furnished with a

certificate from the doctor stating that he is in proper physical condition for such work. No workman shall be kept under compressed air if his certificate has not been renewed 15 days after the first examination and following that once a month. In addition to his periodical visits, the doctor shall examine all workmen who have affections of the nose, the throat or the eyes, or who express a desire to be examined. A daily log of the personnel shall be kept, noting the accidents, and even the most trivial illnesses, which occur to men on the work.

Measures must be taken to keep all alcoholic liquors away from the work. Any workman in a state of intoxication shall be kept away from the work for at least 24 hours.

The compression and the decompression shall be under the surveillance of a special inspector, who shall order the method of operation. In compression the time employed shall be four minutes at least to raise the pressure from 14 lbs. per sq. in. to 28 lbs. per sq. in. of total effective pressure (that is, pressure above atmospheric) and five minutes at least for each additional 14 lbs. above 28 lbs. per sq. in.* The time employed in decompression shall not be less than: 20 minutes for each pressure of 14 lbs. down to 42 lbs. per sq. in.; 15 minutes for each 14 lbs. between 42 and 28 lbs. per sq. in., and 10 minutes for each 14 lbs. below 28 lbs. If the pressure does not exceed 14 lbs. per sq. in., the time necessary to lower the pressure to zero may be reduced to five minutes.

Pressure may not be removed by means of sudden diminutions when the workmen are in the chamber. Each lock shall contain a pressure gage; if the pressure is greater than 14 lbs., a recording gage shall be provided.

The height of the working chamber shall be such that workmen will be able to stand upright in it. In any case this shall not be less than 5.9 ft. The quantity of air in the chamber shall be at least 1,400 cu. ft. per hr. per man, and the proportion of carbonic acid in the air shall not exceed one part in a thousand. In case that the pumping of air into the chamber is stopped, the foreman inside shall require the departure of all workmen after a period of ten minutes. Firing blasts in the working chamber without first having the workmen leave is forbidden, and the workmen are not allowed to return until the atmosphere has become normal.

The amount of air in the lock shall not be less than 21 cu. ft. per person. In the summer, locks exposed to the sun shall be protected by an awning. When there are more than 20 workmen in a working chamber, communication shall be had with the exterior by telephone. Special precautions shall be taken to prevent the falling of any workman down the lock, in case he is overcome with dizziness.

All gates for the men shall be closed on the side of the greatest pressure; all gates for material shall be closed on the side of the least pressure, but they shall be furnished with locks to prevent their sudden opening. All entrance shafts shall be provided with ladders in good condition, and apparatus shall be provided to take out men who are unable to climb. The lock, the shafts and the working chambers shall be lighted by electric light. Special precautions shall be taken to prevent the movement of the men underneath the shaft. Each air supply pipe shall be provided with an automatic valve which will close the pipe when the supply pressure drops below that in the chamber. On the air installation shall be provided with an automatic pressure regulator.

The working chambers shall be supplied with a tube of oxygen under pressure or such other apparatus that in case of necessity a quantity of pure oxygen can be forced into the chamber. When work is carried on under a pressure higher than 17 lbs. per sq. in. an anteroom shall be put next to the working chamber where the workmen, when they leave, may rest. Its dimensions shall be 210 cu. ft. per man. It shall be provided with a washing room and beds. When the pressure in the chamber passes 28 lbs. per sq. in. a chamber of recompression shall be provided to be used as a hospital room.

All apparatus shall be submitted to a weekly inspection.

In a day of 24 hrs. it is imprudent to pass under compressed air a longer time than is noted below.

Pressures below 28 lbs. per sq. in.	8 hrs.
Pressures between 28 and 35 lbs. per sq. in.	7 hrs.
Pressures between 35 and 42 lbs. per sq. in.	6 hrs.
Pressures between 42 and 49 lbs. per sq. in.	5 hrs.
Pressures between 49 and 56 lbs. per sq. in.	4 hrs.

Once a week, at least, an interval of 12 hrs. should elapse between leaving and taking post in the working chamber. When work is being carried on at a pressure above 28 lbs. per sq. in. provision should be made to have the men live within a radius of 1 mile of the work.

*In the original all pressures are given in kilograms per sq. cm.; 1 kg. per sq. cm. equals about 14.2 lbs. per sq. in. and in this translation an equivalent value of 14 lbs. per sq. in. has been used.

Sanitary Conditions in the Philippines.

Sanitation in the Philippines is reviewed in "The Survey" for Nov. 4 by Dr. Victor G. Heiser, Director of Health, U. S. Public Health and Marine-Hospital Service. After presenting a historical review of his subject, Dr. Heiser summarizes what has been accomplished under American supervision as follows:

Nearly 400 boards of health have been organized in the municipalities of the archipelago, and a district-health-officer organization effected, which embraces every province. The new gravity system by which pure water is obtained from an uninhabited watershed, has been completed at a cost of $2,000,000, and Manila has been protected from the danger of the extension of water-borne diseases.

A new sewer system for Manila has been constructed at a cost of $1,650,000, and the esteros and river are protected from sewage pollution. The thirty-one miles of esteros have been dredged and cleaned of the filthy accumulations of years. A complete system of daily street sweeping has been put into effect and crematories have been built for the disposal of garbage.

Five modern market buildings of steel and cement, some of them covering an entire block, have been constructed. The moat around the walled city has been filled and the parking is well under way. Thousands of offensive vaults have been replaced by modern water-closets. The work of reclamation of waste sunken lands has removed the mosquito pest from many districts. Medical aid has been provided in hundreds of remote places and the free distribution of quinine has no doubt saved hundreds of lives. Scores of artesian wells throughout the provinces are supplying pure water to the inhabitants, the result of which in many localities has been the reduction of the death rate by as much as 50%.

Four reinforced-concrete hospitals with a capacity of over 1,000 patients have been erected. The new General Hospital will be conducted, not only to meet the needs of the government employees, but also as a general hospital which will be utilized by the Philippine Medical School, recently established as a department of the university scheme for clinical instruction in medicine. In addition to the medical school and hospital, a veterinary college and veterinary quarantine have been organized.

A new hospital with accommodations for over 400 insane patients has been erected. Two complete, modern marine quarantine stations that will compare favorably with those in any part of the world have been constructed at Manila and Cebu. A new sanatorium has been erected in Benguet, and funds are available for a tuberculosis outing camp. The Culion Leper Colony, the largest in the world, with accommodations for over 2,000 persons, is in full operation, and the provinces have been practically cleared of this loathesome disease. The incidence of leprosy has been decreased from one leper in every 2,000 of the population to one in every 2,800.

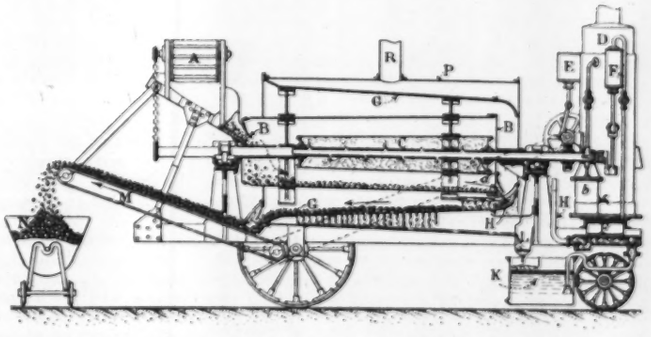
Over 5,000,000 people have been systematically vaccinated, and districts in which over 6,000 deaths were reported annually from smallpox now have only a few scattering cases. Over 10,000 microscopical examinations of stools have demonstrated that about 90% of the inhabitants are afflicted with intestinal parasites, of which over 10% are uncinaria or hook worms. Measures to combat these conditions are being rapidly perfected.

It is doubtful whether the active sanitary campaign is of as much value as the quiet, determined campaign of education constantly conducted. The rules of health are taught in every school in the land and repeated in the homes of the people. Young Filipino women are being educated as trained nurses, and instruction in infant feeding has been inaugurated. The public schools teach the nature and treatment of tuberculosis, and from time to time Bureau of Health men give lectures on sanitary subjects at public institutions.

A Machine for Coating Broken Stone with Tar.

As one stage in the process of making the tar-macadam road it is necessary to coat with tar the small or broken stone that goes to make up the road metal. This can be coated in one of two ways; either cold broken stone is immersed in hot tar or cold tar is poured over hot broken stone. In the accompanying cut, there is shown a section through a machine for coating the stone according to the first of the two above noted methods. The machine, used somewhat extensively in France in the Boltshauser system of tar-macadam road building, is illustrated in the Nov. 13, 1909, issue of "Le Genie Civil."

The apparatus is mounted on four wheels so that it may be easily moved along the road to meet the requirements of material location. Mainly it consists of a loading elevator, a series of concentric rotating drums, a steam boiler with accompanying engines and pumps, and an unloading elevator. In operation the broken stone from the pile is dumped, via elevator *A*, in the bottom of rotating drum *B*, and is carried down the sloping bottom of *B* to be dumped there into drum *G* rotating on the same axle as *B*. In its passage down *B* the broken stone is heated to a temperature between 130° and 150° F. by the cylinder *C*, which is full of steam fed through the hollow axle from the boiler *D*. Water of condensation is led away from the collector *a*, at the boiler end of *C*, through the hollow axle to tank *b*, where it can be drawn off. Tank *F* is filled with tar, which is pumped through pipe *H* to the boiler end of drum *G*, there to be mixed with the hot stone just dropping out of *B*. Led down the slope by gravity, the separate pieces of stone are coated with the tar and are dropped out of *G* onto elevator *M* and are thence dropped into barrows to be carted to the road. The excess tar in *G* drops through openings and finally reaches, via strainer *L* and tank *K*, the pumps *F* to be used over again.



VERTICAL SECTION THROUGH THE BOLTSHAUSER MACHINE FOR COATING BROKEN STONE WITH TAR.

From the cut it may be seen that all of these movements are controlled entirely from the boiler and its accessories, and that the process is entirely automatic from stone pile to barrow.

PRIZES FOR THESES of senior students in the colleges, universities and technical schools of the country, on the subject "Design of an Electric-Railway Car for City Service" are again offered by the J. G. Brill Co., of Philadelphia, makers of cars and trucks. The company's announcement states that the theses need not be undertaken solely for this contest and that professors, railway officials and others may be consulted. The theses will be judged first on technical merit and secondly on manner of presentation of the design. There will be three prizes of $250, $150, and $100, respectively. With the first prize also goes the J. A. Brill memorial gold medal. Full details of the conditions of the competition may be secured from the Technical Department of the J. G. Brill Co.

Effect of Roughness of Bed on Depth of Water and Distribution of Velocity.*

By E. C. MURPHY,† M. Am. Soc. C. E.

In the hydraulic laboratory investigations of the U. S. Geological Survey, two series of experiments have been made with unloaded streams flowing in straight, rectangular channels of varying roughness of bed. The first was made in a wooden trough 150 ft. in length and 0.915 ft. in width and intended mainly to show the relative effect of roughness of bed on the distribution of velocity in vertical planes; the second was made in a trough 31.5 ft. long, 1.0 ft. in width and shows the relative effect of roughness of bed on mean and bottom velocity for various slopes.

The roughness whose effect was determined was produced by covering boards with paraffine, sand or fine gravel. The sand and fine gravel were fastened to the boards with thick paint. The paraffine was applied hot to well smoothed, unpainted boards. The sand and gravel surfaces are designated by the sieve number of the sieves used in separating them. The sizes corresponding to those sieve numbers is as follows:

Sieve No.	Size of opening, millimeters.
50-60	0.31 to 0.27
40-50	0.40 to 0.31
20-30	0.90 to 0.58
6-10	3.50 to 2.10
4-6	5.00 to 3.50

*Data used with permission of the Director and Chief Hydrographer of the U. S. Geological Survey.

†Engineer, U. S. Geological Survey, 2338 Carlton St., Berkeley, Calif.

The discharge was measured by passing it through a rectangular opening under constant head; the depth was measured with a gage reading to thousandths of a foot and the velocity with a Pitot tube and with beans.

Some of the data obtained in the first series are given in Table I.:

In this series the rough board was 16 ft. in length. It was fastened to the bottom of the trough and had a long wedge-shaped board at each of its ends. Three vertical velocity curves were obtained for each surface, one in the center of the trough and one 3 ins. on each side of the center. The means of these three vertical velocity curves are shown in Fig. 1 for each of these surfaces. It should be noted that the scale of depth is ten times the scale of velocity.

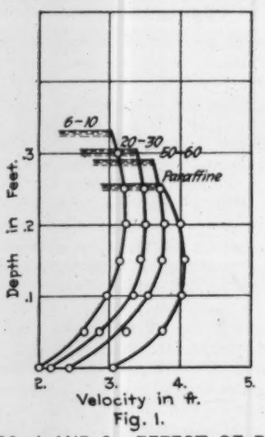


Fig. 1.

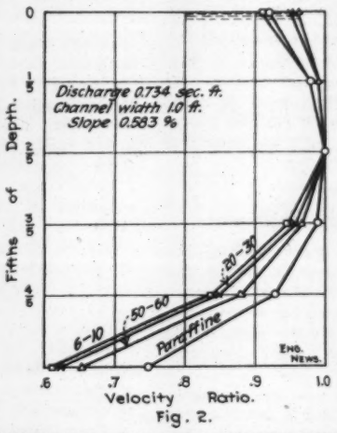


Fig. 2.

FIGS. 1 AND 2. EFFECT OF ROUGHNESS OF BED ON WATER DEPTH AND VELOCITY.

For better comparison of these curves the velocity and the velocity ratio at each fifth of depth have been computed. These velocity ratios are plotted in Fig. 2.

From these data it may be noted:

(1) Roughness changes both the depth of water and shape of the vertical velocity curves. The depth increases with the roughness and the velocity ratio increases as the roughness decreases.

(2) The position of maximum velocity is near 2/5 depth but this ratio decreases slightly as the roughness increases.

(3) The vertical velocity curve for the paraffine surface approximates a parabola with its axis parallel to the water surface and 2/5 depth below it. The equation of such a curve can be written

$$Vx = Vmax - a\sqrt{RS}\left(\frac{dx}{D}\right)^2 \ldots\ldots\ldots\ldots (1)$$

R being the hydraulic radius, S the slope of trough, dx the distance above or below the axis to the point where the velocity is Vx, $Vmax$ is the maximum velocity and D the depth. For this paraffine surface this equation becomes,

$$Vx = 4.06 - 1.624\left(\frac{dx}{D}\right)^2 \ldots\ldots\ldots\ldots (2)$$

The values given by this equation agree closely with those obtained by experiment for the upper 4/5 of the curve.

(4) As the roughness increases these curves become less symmetrical about the axis and differ more and more from a parabola.

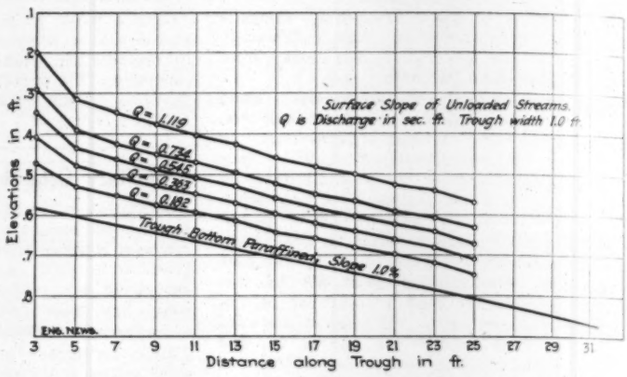
(5) The effect of these roughnesses on maximum, mean and bottom velocity is as follows:

Roughness.	VELOCITY. Maximum.	Mean.	Bottom.
Paraffine	1.00	1.00	1.00
50-60	.94	.91	.84
20-30	.87	.82	.71
6-10	.80	.78	.66

(6) Roughness distorts the vertical velocity curve in a shallow stream more than a deep stream.

Some of the data obtained in the second series of experiments are given in Table II.

Fig. 3 shows the depth and surface slope for the experiments with the paraffine surface. The bottom velocity was obtained with beans having a length of from 5/16 to 6/16-in. and diameter of 4/16 to 5/16-in. They quickly sink to the bed and rolled or bounded along. The Pitot tube was only used in the experiments with the paraffine surface on account of its action on the bed. Sand when free to move scours from under the tube and the velocity shown by it is not that along the sand surface but a short distance above the surface.


Surface Slope of Unloaded Streams.
Q is Discharge in sec. ft. Trough width 1.0 ft.
Q = 1.119
Q = 0.734
Q = 0.545
Q = 0.363
Q = 0.182
Trough Bottom, Paraffined, Slope 1.0%
Elevations in ft.
ENG. NEWS.
Distance along Trough in ft.
FIG. 3. DEPTH AND SURFACE SLOPE OF STREAM IN CHANNEL WITH PARAFFINED BOTTOM.

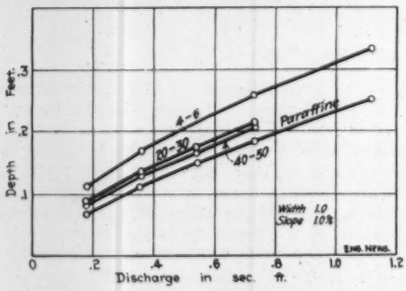


Fig. 4. Effect of Roughness of Channel Bottom on Depth of Water Flow.

RELATION OF DISCHARGE AND DEPTH.—This relation is shown graphically in Fig. 4 for a trough slope of 1%. On logarithmic paper the plotted points for each surface give well-defined straight lines showing that this relation is of the form

$$Q = a\, d^n \ldots\ldots\ldots\ldots (3).$$

The values of a and n are given in the following table:

VALUES OF a AND n IN $Q = a\,d^n$. WIDTH OF CHANNEL, 1.0 FT.

Roughness of surface.	Slope of trough 0.5% a	n	1.0% a	n	1.5% a	n	2.0% a	n
4-6	...	....	9.6	1.8	12.4	1.80	14.2	1.8
20-30	6.2	1.60	8.7	1.6	11.0	1.6	12.3	1.6
40-50	6.4	1.55	8.6	1.55	10.4	1.55	....	...
Paraffine	...	....	8.5	1.45	....	....	....	...

TABLE II.—DATA SHOWING THE EFFECT OF ROUGHNESS OF BED.

Roughness, 40-50 Discharge, sec.-ft.	Depth, ft.	Velocity Vm.	Vb.	Roughness, 20-30 Discharge, sec.-ft.	Depth, ft.	Velocity Vm.	Vb.
Slope, 0.5%				Slope, 0.5%			
0.182	.097	1.88	1.65	0.182	.108	1.69	1.35
.363	.151	2.41	1.74	.363	.169	2.15	1.44
.545	.200	2.73	2.06	.545	.220	2.48	1.61
.734	.241	3.05	2.02	.734	.270	2.65	1.72
Slope, 1.0%				Slope, 1.0%			
0.182	.082	2.17	....	0.182	.088	2.07	1.84
.363	.130	2.79	....	.363	.137	2.65	2.13
.545	.166	3.28	....	.545	.176	3.10	2.46
.734	.205	3.58	....	.734	.212	3.46	2.42
Slope, 1.5%				Slope, 1.5%			
0.182	.078	2.34	2.52	0.182	.078	2.34	2.32
.363	.118	3.08	2.90	.363	.117	3.11	2.72
.545	.151	3.61	3.14	.545	.150	3.63	2.86
.734	.185	3.97	3.02	.734	.185	3.97	3.08
....	....	....	....	Slope, 2.0%			
....	....	....	....	0.182	.070	2.60	2.58
....	....	....	....	.363	.109	3.33	3.20
....	....	....	....	.545	.141	3.87	3.58
....	....	....	....	.734	.175	4.19	3.40

Roughness, 4-6 Disch., sec.-ft.	Depth, ft.	Velocity. Vm.	Vb.	Roughness, Paraffine Disch., sec.-ft.	Depth, ft.	Velocity Vm.	Vb.	Vf.
Slope, 1.0%				Slope, 1.0%				
0.182	.114	1.60	1.12	0.182	.068	2.68	2.32	2.45
.363	.169	2.15	1.40	0.363	.111	3.27	2.71	2.90
.734	.252	2.91	1.62	0.545	.150	3.63	2.81	2.89
1.119	.322	3.48	2.16	0.734	.183	4.01	3.14	3.42
....	....	....	....	1.119	.250	4.48	3.55	3.90
Slope, 1.5%				Roughness, Oil Surface				
0.182	.096	1.90	1.51	Slope, 1.0%				
.363	.140	2.59	1.90	0.182	.067	2.72	....	....
.545	.176	3.10	2.08	0.363	.107	3.40	....	....
.734	.216	3.40	2.28	0.734	.180	4.08	....	....
Slope, 2.0%				1.119	.248	4.51	....	....
0.182	.087	2.10	1.79					
.363	.130	2.79	2.28					
.545	.166	3.29	2.66					
.734	.201	3.65	2.81					

Vm = discharge ÷ cross-section.
Vb = bottom velocity obtained with beans.
Vf = bottom velocity obtained with Pitot tube.

TABLE I.—DATA ON EFFECT OF ROUGHNESS OF BED ON DEPTH AND VELOCITY DISTRIBUTION
Trough Width, 0.915; Discharge, 0.734 sec.-ft.; Velocity in ft. per sec.

Distance above bottom, ft.	Paraffine. B.	C.	D.	Mean.	50-60 Sand. B.	C.	D.	Mean.	20-30 Sand. B.	C.	D.	Mean.	6-10 Sand. B.	C.	D.	Mean.
0.00	3.14	2.89	3.09	3.04	2.52	2.30	2.51	2.44	2.22	2.01	2.31	2.18	2.06	1.76	2.17	2.00
.05	3.92	3.51	3.88	3.77	3.40	3.04	3.29	3.24	3.00	2.55	3.08	2.88	2.75	2.36	2.85	2.65
.10	4.17	3.80	4.08	4.01	3.75	3.31	3.59	3.55	3.65	2.86	3.52	3.34	3.12	2.65	3.12	2.96
.15	4.14	3.92	4.13	4.06	3.87	3.58	3.82	3.76	3.61	3.09	3.64	3.45	3.30	2.82	3.30	3.14
.20	4.02	3.92	3.99	3.98	3.84	2.68	3.82	3.78	3.61	3.29	3.64	3.51	3.32	3.05	3.37	3.25
.25	3.68	3.74	3.70	3.82	3.85	3.63	3.68	3.72	3.57	3.42	2.57	3.52	3.27	3.14	3.32	3.24
.30	....	....	....	....	....	....	....	....	....	....	....	....	3.07	3.10	3.19	3.12
	Depth = 2.58 Vm = 3.15				Depth = .291 Vm = 2.75				Depth = .305 Vm = 2.63				Depth = .332 Vm = 2.41			

C = center of trough.
B = 3 ins. north of trough center.
D = 3 ins. south of trough center.
Vm = discharge ÷ cross-section.

The exponent n is seen to decrease as the roughness decreases and to remain constant as the slope increases. The coefficient a decreases as the roughness decreases and increases as the slope increases.

RELATION OF DISCHARGE, SLOPE AND DEPTH.—The coefficient a is a function of the slope for a given surface and can be written:

$$a = K\,S^m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4).$$

The log plot of this equation is a straight line for each roughness of surface and we have the following values of K and m:

VALUES OF K AND m IN $-a = K\,S^m$.

Roughness of surface.	Values of K	Values of m
4-6	9.6	0.56
20-30	8.7	0.50
40-50	8.6	0.46

Both K and m decrease as the roughness decreases.

Since $Q = K\,S^m\,d^n = d\,w\,Vm$ we have

$$Vm = \frac{K}{W}\,S^m\,d^{n-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Vm being the mean velocity and W the channel width.

For the 40-50 roughness

$$Vm = 8.6\,S^{0.46}\,d^{0.46} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6).$$

Fig. 5 shows graphically the relation of discharge to mean velocity, Fig. 6 the relation of discharge to bottom velocity. The relation of the velocity of water along a surface to the velocity of a body moving in the water that touches the surface at intervals has not been fully investigated.

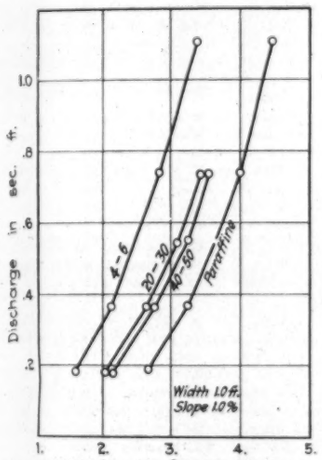


Fig. 5. Relation of Discharge to Mean Velocity.

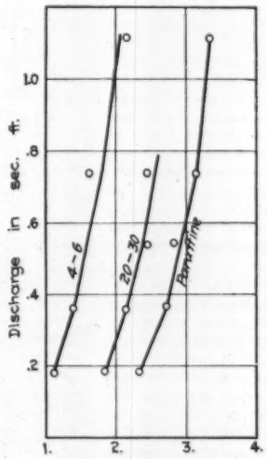


Fig. 6. Relation of Discharge to Bottom Velocity.

FIGS. 5 AND 6. RELATIONS BETWEEN DISCHARGE AND VELOCITY IN EXPERIMENTAL CHANNELS WITH BOTTOMS OF DIFFERENT ROUGHNESSES.

It appears that the coefficient and the exponent of both slope and depth increases as the roughness increases.

A COAL ELEVATING WHEEL is a curious type of machine installed by the Hungarian Southern Ry. for coaling locomotives at Nagy-Kanizsa. The wheel is about 16½ ft. diameter, and its journals are carried in frames on a four-wheel car fitted with small wheels running on a narrow-gage track. The rim of the wheel is only a few inches above the rails. The rim is of trough shape, closed on the outer circumferences, and is divided into compartments by diaphragms which are set at an angle with the vertical axis of the wheel. Under the inner circumference at the top of the wheel is an apron which receives the coal dropping from the compartments, and this is fitted with a hinged chute to deliver the coal to the tender on a track parallel with that of the machine. The machine is pushed into position, and held by four vertical screw jacks fitted with shoes which rest on the rails.

Men with wheelbarrows deliver coal into the bottom of the wheel, inclined planks leading up to the level of the car frame. A small motor on the car drives the wheel by means of a circular rack on the rim. This peculiar apparatus was described in the September number of the "Revue Generale des Chemins de Fer."

Requirements of Engineering Files and Indexes.*

By HERMAN K. HIGGINS,† Assoc. M. Am. Soc. C. E.

When, some 18 years since, the writer entered the engineering service of a certain railroad, not so large then as later, their drawings were roughly classified as land, track, bridge, building and miscellaneous plans. There was no index; plans were supposed to be put away in their proper drawers. Finding a plan was very simple; we looked in its proper drawer. If not there we looked in any other drawer that seemed likely to contain it. A few years later the writer was transferred from construction to office work and it became part of his duty to keep run of the plans and records pertaining to bridges. By that time the track, building and land plans had been sub-classified according to geographical location, one drawer for each division, etc. Bridge plans had also been subdivided, on the basis of Blueprints v. Tracings v. Brown paper, etc., single structures appearing in all the classes.

One of the writer's earliest innovations was the sorting out of plans pertaining to each structure without regard to quality of paper. These were then fastened together, marked with the number of the bridge and kept flat in order of such numbers, one drawer for one or more geographical divisions of the road. The bridge numbers were geographically consecutive; each branch began with number 1, and the numbers progressed as far as necessary. The most undesirable feature was the necessity for interpolating whenever a new structure is established. As long as the original numerical system for interpolation is adhered to, there is little trouble, but the addition of letters combined with pre-existing fractions results in some such combination as 10¾ E a.

The writer believes it rarely necessary to change a system of bridge numbers, and, if such system goes back well into the past, such change usually involves the loss of many valuable data, as the old numbers are forgotten in a few years and the many references in old requisitions, letters, notes, etc., become thereby unavailable for all following seekers after data.

This self-indexing system worked very well as long as drawer room was available. In course of time the road, with several others, was absorbed into a larger system, the offices were consolidated and it became necessary to store the plans in a fireproof vault. They had to be rolled, and the self-indexing feature had to be abandoned and an index provided.

One of the consolidating companies already had a book index, or, rather, list of plans of all kinds classified according to name of nearest passenger station. The bridge plans were often found rolled up with plans of other work, cross-sections, profiles, maps, masonry, earthwork, station plans, etc., all in the same roll. The system of numbering rolls was very simple. It began at 1 and had reached some 6,000 odd at the time the writer made its acquaintance. The book in which the index was kept was divided alphabetically. Each station had assigned to it a certain amount of space as its importance seemed to warrant, the stations being as far as possible alphabetically arranged. The arrangement of titles under the station names was chronological, as it was not practicable to continue and maintain the alphabetical arrangement.

In filing the plans of the other component roads it was attempted to continue and expand the above principle, but a number of difficulties arose. Another of the component roads had a really excellent index, well classified and with all necessary data entered therein. The serious fault with the index was that it was divided by operating divisions of the road; these often change, and in this case had changed several times. Each division had a separate book, and to find a plan the seeker must either know which division it had pertained to at the date of filing or must look through several books.

At the time above mentioned of expanding the "station name" system of filing, the card system was introduced, largely through the writer's recommendation, the book mentioned being all copied on the cards. This formed the nucleus for the present rather satisfactory index on the road in question.

Long before the consolidation of the roads the writer had foreseen the need for a comprehensive index and had taken up somewhat thoroughly the study of indexes and self-indexing systems. There was at that time very little in print on the subject, and he was obliged to begin nearly at first principles. By the time the consolidation of the offices and consequent rearrangement demanded action in caring for bridge data, a system was well outlined and the details presented little trouble. The writer has since formulated the system in the following specification, if it may be so called. It is intentionally simple, and, so far as applied, worked perfectly for some four or five years, growing all the time. It could not be fully applied to the case in point as there was much conservatism to be overcome and little intelligent clerical assistance to be had.

The "specification" is made as full and complete as possible, the fundamental principles and the "reasons why" are given in considerable detail to the end that it may be clear and perhaps useful to readers who have indexes to make. The "specification" is discussed under the following heads and sub-heads outlining the requirements for an engineering office:

(1) GENERAL CONSIDERATIONS.
- Index v. self-indexed files.
- Notes, memoranda, etc.
- Letters and old books and papers.
- Plans.

(2) DEFINITION & SCOPE.

(3) FORM.
- Facility, simplicity, certainty.
- Cards v. book.
- Size and quality of cards.
- Arrangement: Alphabetical or otherwise.
- Number of indexes.
- Speed v. certainty.
- Cross indexing.
- Elimination of dead matter.

(4) PLAN FILES.
- Form and size.
- Numbering units.
- Numbers on plans.

(5) BOOK AND DOCUMENT FILES.

(6) COMPUTATIONS, DIAGRAMS, etc.

(7) CONCLUSION.

(1) GENERAL.—A business just starting usually requires no elaborate filing system as the person in charge of the office can remember where things are. As the business grows, data and records accumulate and more men are employed. It then becomes necessary to systematize and to keep all data where not only the chief, but also the assistants, can find them at short notice. At this point we meet an alternative: we can file in a self-indexing system, or we can file in any convenient form, and index the file.

In case the data are of suitable nature and form, the self-indexed file is usually the better and cheaper. In collecting data it is well to put them into convenient form for such files.

The writer has for years kept notes of surveys, inspections, formulas, diagrams, etc., and memoranda of all kinds, on ordinary Library Bureau cards. The larger size, about 4 by 6 ins., is preferable for field notes of surveys; for most other purposes the standard size, a trifle less than 3 by 5 ins., is preferable. For field use they are tied together into book form with stiff leather covers. They are filed by subjects in an ordinary cabinet of standard form and size. After cross referencing they are absolutely and permanently accessible.

For extended surveys covering many pages, and for work in which notes cannot be put on sketches but must be kept with them, an ordinary book is sometimes preferable. Moreover, such survey notes once plotted rarely need to be referred to again and the book is convenient enough; but for detached surveys, notes of inspections and, in general, all divisible work, cards (or loose leaves) have great advantages. They may be sent into the office for draftsmen's use without interruption to the outside work, and returned if necessary, or filed. On city or town survey work it is much easier and safer to carry a dozen or so cards bearing notes of former surveys of tracts adjacent to the one under survey than to carry as many old notebooks. Those of us who have done much city work, so-called, do not need to be told that old notes are likely to be of very great value in such work. If it is attempted to copy them into the current notebook, one is likely to omit the one thing most important, which omission is discovered later in the field.

Records of bench marks, reference points and the like are very conveniently kept on cards and tied into the back of the made-up notebook. The cards should preferably be kept in the office when not in actual use to attain greater safety against loss or accident.

The loose-leaf notebook which operates on the same principle, that of devisability, has many friends and the writer prefers it to the old-fashioned book, but he has found the cards easier to care for and more accessible when filed. This principle of devisability is the same as that requiring letters to treat one subject only on each sheet; this principle is almost universally applied to correspondence, and its recognition in technical files will prove as profitable as it has already proved in letter files. Many other applications of this principle will suggest themselves; the main point is to plan beforehand for the filing and to get the original data in convenient and devisable form. The writer has several professional acquaintances who use this card system for field notes, memoranda, etc., and who would not abandon it on any account. Usually letters, bills, receipts, time returns, requisitions and most clerical papers can be

*Parts of a paper, "A specification for Filing and Indexing Railroad Plans," read before the Boston Society of Civil Engineers, Jan. 27, 1909.

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kept in a self-indexed file, which may well be cross referenced in the general index. Some offices own as most valued possessions old plans, notebooks, etc. These are usually not susceptible of self-indexing; old plans almost never are. They must, therefore, go into an indexed file.

(2) SCOPE.—The dictionaries tell us that the word "index" signifies "to point out." An index is usually conceived to be a contrivance to enable one to find something the location of which he does not know. It does this, but if properly made will do much more. It should at least answer with speed and certainty the three questions, (1) "Is there on file anything pertaining to the subject in hand?" (2) "What is there?" (3) "Where is it?" It should in addition give such particulars as scale (if a plan or sketch), date, source of information, and such description as will fully identify the data in the mind of the seeker. A thoroughly worked out index should also have references to pertinent data known to exist in other offices, whether or not such office is allied to the indexing office; data on public record, data contained in professional or trade books or journals, and, in general, to any source of data which are likely to be useful.

(3) FORM.—The form of an index must necessarily vary according to the needs of each particular office and should have the following general qualities: (1) It should be easy to handle, to reduce to a minimum the cost of using it. (2) It should be simple, to enable its use by persons of little education, *i. e.*, the lower grades of help employed in technical or other offices. (3) It should be certain, to enable a person of ordinary intelligence to run down speedily the desired data, and be sure none has been overlooked.

One is tempted to assume that, in this age of cards, no one would dream of putting a current index into a book. A finished index, e. g., an index to a treatise, is, of course, not to be confounded with a current index, which forms the subject under discussion.

There are just two apparent advantages in a book, (1) the index is always together, and (2) no part can be lost without losing the whole. The first advantage is apparent only, as indivisibility is, in an office of any size, a disadvantage, as only one person at a time can use the index. The second is fallacious in that the loss of any part of an index is in any event only a matter of office discipline; a full drawer of cards cannot easily be lost, and only the indexing clerks should ever be allowed to take cards from their places in the drawers.

The positive advantages of cards really include all the advantages of a good as opposed to a poor index and all that follows may also be taken as an argument for cards (if, indeed, argument is needed). Perhaps the most important of such advantages is that it allows the fullest use of the alphabetical form; this eliminates the loss of time each time the index is used, caused by having to read page after page of irrelevant matter. As such reading is almost necessarily hurried over, and to some extent slighted, the element of certainty is to that extent lost.

Quality, manufacture and size of cards.—The quality and size of cards is of some importance. The paper used should be tough, hard and close grained, heavy enough to handle easily and not too heavy to bend safely.

Perfection of manufacture is very important as it governs the speed, and, to some extent, the certainty of the index. The cards should be all of exactly the same size, edges should be clean and square. These two qualifications especially should be insisted upon, even at considerably increased cost. The cost of the stationery is in any event a very small fraction of the total cost of the index, and it is truest economy to buy the very best the market affords. Good cards cost money to make; poor ones are almost worse than none. The same is true of cabinets in which to store the cards; the best are none too good. Size is a matter of personal preference. The writer has used nearly all sizes to some extent, and for indexes proper prefers the 75 × 125 mm. size, a trifle under 3 × 5 ins. They are large enough and not too large for comfortable handling.

Arrangement, alphabetical or otherwise.—There is in the human mind a strong tendency to specialize and to complicate. Accordingly we find in much filing that some arrangement other than alphabetical is adopted. The non-alphabetical arrangement presupposes knowledge on the part of the user of the system upon which the index was constructed. This means that each newly employed assistant must learn the system before he can effectively use the index. In case the system is complicated, as a non-alphabetical system almost necessarily is, he must devote a considerable amount of time to learning it, which time has to be paid for by some one and is a dead loss. New men are likely to form a considerable fraction of the force, and the loss of time learning systems of records amounts to considerable. The alphabetical arrangement is intelligible to any one who would have occasion to seek for data in such index, and enables the utilization of low-grade help,—office boys, messengers, etc.

In the indexing of records of an engineering office the question "how many" is sure to arise. The tendency to complicate mentioned above here asserts itself, and there are in some offices as many indexes as there are varieties of records. The writer believes in as few indexes as possible, keeping permanently valuable technical records separated from clerical records and records of ephemeral value. If the filing is done comprehensively, even this division is superfluous, as with cards it is always possible to eliminate obsolete and to insert additional matter.

Speed and certainty.—Speed is important and is attained partly by the free use of guide cards, but more by comprehensive planning in the beginning. Certainty is by far the most important element in the use of an index, and can only be attained by careful, painstaking work by competent persons, in making and keeping it. Who does not know that feeling that the reason for his non-success in seeking is solely that he has looked for the wrong word and that the desired data must surely be at hand. It is still more important in making additions, or in eliminating dead matter, to make sure that nothing has been done to obscure old data, or separate data that belong together. These several forms of certainty involve, after careful work, the intelligent use of cross references.

Cross indexing, or, preferably, cross referencing, is essentially a reindexing under an additional caption; e. g., a bridge plan should be indexed under the name of the street or river, under the number, if numbered, under the name of the township, if named, and under the name of the nearest station if on a railroad, and often under many other captions. Many filing clerks put the file number on all the cards. This is wrong; *the number should appear only under the most important and permanent caption*; all the others should refer to that caption instead of to the file number direct. There are several reasons for this; it is sometimes necessary to move records to another place; it is sometimes necessary (convenience may be a form of necessity) to divide or to reindex the data referenced on one card; it is often desirable to eliminate obsolete records. If only one card bears the file number it is very easy to change it or to insert a substitute, or to enter the permanent record of elimination; in such cases the cross references do not need to be disturbed. In case the file number appears also on the cross reference cards, a change of any card must be entered on all, and if by inadvertence one be missed, it will surely make trouble in the future, and may cast a doubt on the correctness of the whole index. These errors are in practice certain to occur; they can be minimized only by a complicated system of recording all cross references. Why do so when the error may certainly be avoided by the simple expedient of numbering a single card?

Many cross references mean increased certainty, provided numbers appear on one card only; otherwise many references mean decreased certainty. The writer has often been asked such questions as "Where is the Widow Dean bridge, the Narrow passage ferry bridge, India bridge?" etc. Such questions always indicated the need of another cross reference card. Some one knew the answer; when it had been looked up, and the card inserted, any one could easily find the desired data. It will be objected that it takes time to look for a second card. True, and the extra time is unimportant compared with the certainty that all data on file will surely be found on that card. It may be worth thousands of dollars to be able to produce a particular plan in court; unless some one hears of it who happens to have known that the plan exists and was filed and looks it up, the matter will go by default; the production of other plans will in such case obscure the existence of the one really valuable plan. Of course, instead of a plan it may be a modification of a lease or agreement, or data of agreement as to classification of a cut, or terms of a contract for extras, etc. The main object of an index is to enable one to find data he does not know of, and this object is defeated under the circumstances noted.

In case of cards referring to data, plans, etc., in other offices, public record offices, etc., it is usually best not to attempt to give file numbers, but rather to refer to the office only and describe the plan or data, depending on the local index for more particular location. The reason is that files are apt to be changed or may be divided and rearranged. References that are not permanently correct are inadvisable in an index, as they may become misleading.

The writer's experience indicates that the best form for bridge index is as follows: Primary index. Name of street or river. This card is made as nearly complete as possible, thus:

MAIN STREET BRIDGE 114, MILLSDALE, PA.

Iron — BBW — shop — Bl — 10 shts — ¾ in. = 1 ft.—'04	14 – 17 – 3
Abuts and Piers — Trac — 4 shts — ½ in. = 1 ft.—'04	12 – 27 – 14
Floor — RR — Trac — 1 sht — ½ in. = 1 ft.—'05	14 – 25 – 10
Railing — RR — Trac — 1 sht — 1 in. = 1 ft.—'04	14 – 10 – 17
St. Ry. tracks — St Ry — Bl — 4 shts — ½ in. = 1 ft.—'05	14 – 11 – 4
Notes of survey	See survey file
Stresses for class E street car	See computation file

In case there are many plans of one structure the writer has found it advisable to index under the sub-captions, site, masonry, superstructure, track, floor, etc., grouping the plans or notes under each sub-caption on one or more cards.

Cards bearing survey and inspection notes, computations, memoranda, etc., should be cross referenced as above in the general index. This insures that references to all data on any particular subject will be together and none will be overlooked. Reports, requisitions, some letters, etc., if of permanent value, can probably be cross referenced the same way in the main index. Cards bearing survey notes, etc., (original data), also computations, should, when possible, be kept in a fireproof vault. The general index should be in the most accessible place, in a good light and convenient to get at. The ideal arrangement is a stand on casters or wheels, capable of being easily put into and kept in the vault when the office force is absent.

The elimination of dead matter from a file or index presents some very serious problems. It is so very easy to err in judgment, and, in the interest of convenience, to discard data or notes of no apparent present value, which by some unforeseen circumstance become valuable later. On the other hand is the danger of loading down the file with much non-pertinent and obsolete matter. Non-pertinent matter should not get into the file. It sometimes does and with obsolete matter may need to be removed. The writer believes that, as a rule, the index should include all obsolete data on file. The card should be marked "obsolete" or "obs." opposite each such item, and when the card is finally removed it should be kept in a special "obsolete" case or drawer for at least one or more decades.

(4) PLAN FILES.—Plans and drawings of all kinds should be filed in drawers or pigeon-holes of suitable size. Any one who has looked for a profile or narrow drawing rolled to, say, 12 ins. long, in a 48-in. drawer or space, will not need to be told why. The writer has seen highly-paid men, after the clerks had failed, attack a pigeon-hole containing 30 or 40 rolls, and deliberately withdraw each roll separately, expecting to find the desired plan in the back end of the space behind the other plans, and consequently not visible nor accessible without such process.

This fault is usually due to some official or chief clerk, who seldom uses the file, wishing to keep all plans of some class or division together in a certain location. It will readily be seen that if the index is consulted to learn the space and file number it is entirely immaterial in which case or drawer the plan is kept. It should, therefore, be placed where it will be kept most accessible and best protected. A 12-in. roll behind a 45-in. in a 50-in. pigeon-hole is in serious danger, and is itself a serious danger to other plans, as such a file will abundantly testify.

The form of plan files is subject to very wide divergence of opinion; drawers and pigeon-holes seem to be preferred, also racks in some cases. The writer prefers for drawings of reasonable size, say up to 30 × 60 ins., a filing case containing drawers or sliding shelves not more than 3 ins. deep inside, 2 ins. even better, of size to suit the drawings, in which the plans, tracings, etc., are kept filed flat. The drawers should have non-corrosive sheet metal corner covers at the back, and springs at the front corners, to hold all four corners of the plans down in place.

For rolled plans of considerable length, similar drawers can be used, but the writer prefers a case of pigeon-holes or shelves with partitions. Each unit space, drawer or pigeon-hole can profitably be made to hold 40 or not to exceed 50 sheets or rolls. In some climates it is necessary to provide damp-proof tubes in which to keep the rolls; these may well be of size to hold thirty or more drawings and fit into the filing case. Spaces in all filing cases should not be too deep, and a reasonable assortment of sizes should be provided, as every office needs to preserve plans or prints from other offices, which do not conform to its standards for size. This difficulty is sometimes met by rolling each plan around a stick or tube of standard length, which bears on its end the file number of the plan it belongs to. This has the advantage of keeping the plan in excellent condition, but introduces a chance for error in rolling, inadvertently, a plan on the wrong stick. It is also uneconomical in space and weight, as well as in first cost. Of course expense should be incurred only when the resulting advantage is worth it.

The limit of 50 plans or rolls to each unit is based on observations of employees and is, of course, a compromise. The cheaper the labor employed looking up plans, the larger the unit can profitably be made. It is usually of advantage to plan the units of size for 50 plans, and leave them partly filled. Offices having many standard size plans or plans and maps in sets find the shallow drawers, or sliding shelves, a profitable investment, as they save many times their cost in wear and tear of plans.

Numbering File Units and Plans.—It is usually possible to devise a system of numbers at once so simple that it is obvious and so comprehensive that it will provide for indefinite expansion. The number of digits used should be as small as is consistent with comprehensive-

cess, and they should be combined to give as many permutations as may be. All present and probable future sub-offices and branches should be included.

A large engineering office or department would naturally include a vault for fireproof storage, a main drafting-room, several specialists' rooms, a clerical office, and, perhaps, a number of local survey or construction offices. Each of these would have a file of plans and records, and nearly every one an index of its own plans and records at least. It hardly needs to be stated that there should also be a general index, accessible to all, and preferably located near the vault and main drafting-room. All these should be covered and differentiated in the first figure or digit of the plan number, e. g., a number beginning 01, 11, 21, might refer to a plan in the vault, in the main drafting-room, in the bridge specialist's room respectively. It would be a large department that would require more than ten such offices or rooms. The second figure or digit should refer to the filing case or bank of such cases. For any one at all familiar with the file, it would be unnecessary to remember these numbers, as they would represent so large a section of the file that they would automatically represent the idea of the location, leaving the mind free to remember the remaining more characteristic numbers. At the same time, a new employee could soon find any case desired.

In subdividing filing cases or bank of cases, it is usually possible to number by groups of ten, making it easy to locate a given number. Especially when designing such cases this should be kept in mind. It is as easy to divide a given space into ten as into twelve parts, and the convenience so attained is a very great gain, well worth the trouble involved.

The third, fourth and fifth digits, which should preferably be separated from the first two by a dash or hyphen, as on the sample card shown, should represent the ultimate file unit, pigeon-hole or drawer, and give latitude enough with properly arranged cases, for a very large file. Ten thousand file units in a single room are really too many for safety, and before this number is reached the file should be expanded into another room. The final two digits number the individual sheet in the file.

It may occur to some one that it is not desirable to file plans in a drafting-room or a specialist's room, and that all plans should be filed in a vault or fireproof room. There is undoubtedly opportunity for good judgment in deciding which plans to leave out of the vault and which to put in; nevertheless it is now, and without doubt will continue to be, the custom of all or nearly all engineering offices to keep some or many of their plans in such places, and there is a large class of plans that can be properly so kept. These plans should be indexed in the general index, and should form an integral part of the one comprehensive file. In case plans are moved from one room to another it is not difficult to correct the index if the numbers are properly kept on one card only, as specified above. It need not be said that some one man, preferably a clerk, should have it a definite part of his duties to attend promptly to all filing and changes of file numbers. He should, of course, be governed by carefully drawn rules, should be always and in detail under the direction of the chief draftsman or office engineer, whose time is not thereby wasted, as is often assumed, but is a good, often a very good, investment. One of the ablest engineers known to the writer once told him that "he had only one man good enough to file and index plans, to wit, his highest paid subordinate." In a busy office the chief will rarely be able to find time to actually do the indexing himself; he must then leave the actual work to a file clerk, but should supervise it closely.

The file clerk should preferably put away all plans after they have been used, to insure their getting into their proper places, and should see to it that all tears, rents, folds, etc., are attended to.

The files, and especially the indexes, should be open to the use of all employees of the office, whose duties require use of the plans or data filed. The practice of having files and indexes open to the examination of file clerks only is vicious in the extreme; though fortunately not common, it is still met with often enough to require its mention and condemnation. A file clerk is rarely omniscient; he is usually less intelligent than the average draftsman, who will nearly always be able to run down a desired plan far more quickly and certainly than the file clerk. Complicated or difficult searches for old and poorly indexed plans or data are, of course, possible only where files and indexes are open to the use of the draftsman or specialist who knows what to look for, and the various names by which the data may have been known and filed.

The above does not cover sets of plans like the Geological Survey, for example. The writer prefers for such plans an index sheet showing the boundaries of the various sheets, the plans proper being practically self-indexing by latitude and longitude, or, if necessary, by a letter and number. The reference in the general index would be to the set, and the index number should appear on each sheet of the set, to insure its reaching its proper place in the file.

(5) BOOKS AND DOCUMENTS.—Books are apt to be unsatisfactory from a filing standpoint. They usually contain many subjects more or less closely related to the title; to index them comprehensively requires much time, and anything less falls short of what an index should be. A careful reading of the book is usually a prime necessity, and to be satisfactory this and the indexing must be done by some one conversant with the subjects treated. The bulk of the indexing proper is cross referencing. Periodicals are not so bad, as the amount of pertinent matter is less. Trade circulars and catalogs are often very complex, and only rarely contain permanently valuable matter. Those that do will repay careful indexing and cross referencing; some of the data they contain may be invaluable.

Documents are analogous to plans. Large files of deeds, leases, etc., can sometimes be profitably indexed on a map of suitably small scale. In such case the general index should have a reference in general terms, e. g., "Deeds," see Deed File, Map No. 26—32—; Leases, see "Deed," etc. (the file occupying the unit 26—32—), the individual deed, lease or whatever it is, being filed by a number on the index map. Isolated documents should be treated the same as plans.

(6) COMPUTATIONS.—Computations have in the past usually been kept in books, and more or less, usually less, comprehensively indexed. The writer believes there is a better way, and has seen it in use in a very few offices. Computations should be made on paper of standard size to fit standard filing cases—typewriter size is about right. The computations proper, with the data, diagrams, sketches, reference to notes, etc., all on the standard paper, ruled or plain as needed, are held together by a suitable fastener and kept in a self-indexed, cross-referenced file. Many years' experience has taught the writer that, whenever possible, copies of all original data, memoranda, etc., should be filed with the computations, also copies of diagrams used, or at least a reference to some other computation where the same diagrams have been filed. The writer has had occasion many times to refer to old computations of bridge stresses, where no definite load diagram was referred to. It was a long, tedious job to work it back from the figures given. He has of late years made it a practice to keep load diagrams, tables, etc., on tracings of about 5 × 7 ins., a print being gummed at one end and fastened into the computation book where needed. Of course this is an office where the rules required books to be used.

(7) CONCLUSION.—Since the above was first written down, some five years ago, there have been a number of systems for indexing proposed in the technical press,* many of which the writer has seen and studied. Of these many are excellent provided the index is of limited scope, and is to be used only by highly trained men. The writer has seen none up to this time, and has seen mention of none, which meet the fundamental requirements laid down here, viz., simplicity sufficient to allow its efficient use by relatively unintelligent help, certainty, as outlined above, and wide adaptability.

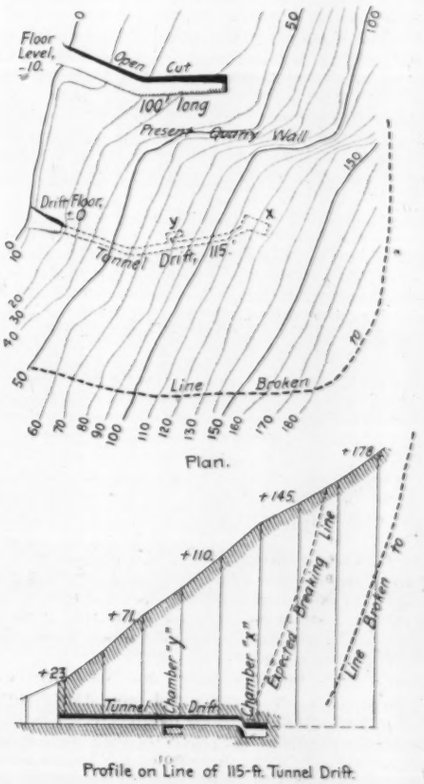
A Large Blast at Morena Dam, California.

By M. M. O'SHAUGHNESSY,† M. Am. Soc. C. E.

On Aug. 30, 1909, a very successful explosion of 19.475 tons of powder was made near the site of the Morena dam, in which 180,000 tons of granite rock were displaced. The Morena rock-fill dam, of the Southern California Mountain Water Co., is situated about 35 miles in an air line southeast of San Diego. (See Engineering News, Nov. 26, 1908, p. 580.) Work was resumed on the construction May 6, 1909, after a suspension of operations since April, 1898. About 150,000 cu. yds. of rock fill is to be put in place. The old work was to an average elevation of about 30 ft. before the new construction was commenced. The rock has been put in place by means of two cableways which span the dam site as well as by two tramways and several derricks. The whole formation of the adjacent hill, from which the material for the dam is taken, is in solid granite, and as the cableways are situated at a level of over 300 ft. above the site, a splendid opportunity presented itself for making a mass shot, with a large charge of powder, without endangering in any way the plant or the formation.

For this purpose an open cut was driven 100 ft. long and 12 ft. wide (see accompanying figure) at the base of an old quarry. Parallel to this and 100 ft. distant, a 4 × 5-ft. tunnel drift 115 ft. long was driven and 70 ft. back from the portal a small chamber (Y), depressed below the level of the bottom of the drift, was driven for a 3¼-ton powder charge. At the extreme end of the tunnel drift a chamber (X) 8 × 8 × 14 ft., depressed and staggered from the general direction of the tunnel, was made for a 6.225-ton powder charge. The grade of the tunnel drift was also 10 ft. above the level of the open cut, conforming to the natural dip of the formation, which was about 10° to the southwest. This layout was designed to throw the broken rock into the area above the open cut, and it was successfully accomplished by the explosion, which took place on August 30, at 4.20 p. m.

In the large chamber there were 371 boxes (each 50 lbs.) of 7% and 9% "Champion" powder, 38 boxes of No. 2 40% dynamite, weighing 2,000 lbs., and 40 boxes of No. 1 60% dynamite, weighing 1,900 lbs., in all 32,450 lbs., or 16.225 tons. In the smaller chamber there were 100 boxes of 7%



Plan and Profile of Large Blast Near Morena Dam, Cal.

"Champion" powder, weighing 5,000 lbs., and 30 boxes of No. 2 40% dynamite, weighing 1,500 lbs., in all 6,500 lbs., or 3.25 tons.

COST OF SHOT.—The detailed costs were as follows:

Tunnel drift and loading	$2,478.15
Open cut	3,499.80
Powder in chambers	3,116.00
Total	$9,093.95

From this must be deducted 1,400 cu. yds. of solid rock excavated from the cut and the tunnel, worth $1,400, which left a net cost of $7,693.95, or 4.274 cts. per ton for 180,000 tons.

DESCRIPTION OF LOADING.—In large blasts where powder forms the bulk of the charge it is preferable to sink pits below the floor level of tunnels or drifts to hold the charges, on account of the greater facility with which a loose powder is loaded into a pit, since greater compactness of the charge is obtained by the men in the pit constantly treading the powder while placing the charge in position. In addition, the sides of a pit offer greater resistance than it is possible to obtain where the powder is loaded directly into the end of the tunnel or drift. The greater resistance

[*For recent articles on indexes and files for engineering offices, see Engineering News: 1898; Part 2, 273, 276: 1901; Part 2, 147, 218: 1902; Part 1, 4, 283; Part 2, 72, 352: 1903; Part 1, 108, 281, 356; Part 2, 369, 505, Lit. Sup. 13: 1904; Part 1, 304: 1905; Part 2, 59, 380: 1906; Part 1, 152, 272, 474; Part 2, 108, 207, 335, 382, 660: 1907; Part 1, 151: 1908; Part 2, 137: 1909; Part 2, 39, 251, 377.—Ed.]

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offered by the pit is of the utmost importance as the resistance offered determines the quantity as well as quality of explosive necessary to obtain results, and maximum results will be obtained only where the powder has been confined until the maximum pressure has been attained. The seemingly large primers of dynamite used in this blast, viz., 2,000 lbs. of 60% and 1,900 lbs. of 40% in the tunnel pit (X) and 1,500 lbs. of 40% in the drift pit (Y) were used first to obtain instantaneous maximum pressures, this being dependent on the rate or speed of detonation of the dynamite, and secondly, for their percussive action. Of course the rate of detonation and percussive action of the dynamite greatly outstrip the maximum pressure developed by the powder.

The first step in charging the tunnel pit (X) was the introduction of about 10,000 lbs. of powder, then 2,000 of 60% dynamite in a semi-circle stacked two boxes high in contact with the west wall of the pit, then 1,900 lbs. of 40% dynamite was stacked in a similar manner against the east wall of the pit. The percussive action of these primers was to start a break or shear in the rock about two feet below the tunnel floor and in a plane parallel with the tunnel floor, allowing the more slowly forming gases of the powder to expand horizontally, thus giving a greater horizontal purchase and preventing the formation of a crater or blowout. The remainder of the charge of powder was placed on top of the dynamite primers all spaces being filled completely with the loose powder. The drift pit (Y) was loaded first with 2,500 lbs. of powder loose, then a primer of 1,500 lbs. of 40% dynamite was stacked two boxes high along the north wall of the pit on top of the powder with the intention of starting a break or horizontal shear in the direction of the tunnel pit. The remainder of the charge, 2,500 lbs. of powder, was then placed in the pit and on top of the dynamite primer.

The wiring consisted of 20-ft. double-strength electric fuses from each of the three primers of dynamite to the main tunnel, where they were connected in series to the battery at the portal. The wire connections between the primers was a No. 16, B. & S. gage, insulated copper wire from the battery to the pit "X" 60% primer, thence to the pit "X" 40% primer, a No. 24 insulated copper wire from this latter to the pit "Y" primer and thence a No. 16 wire back to the battery. Wires were covered with 6 ins. of fine dirt for protection and were further protected at the drift portal by being enclosed in a grooved board laid across the portal and covered with dirt. The resistance of the circuit at the tunnel portal was 8 ohms (Dupont galvanometer).

The first tamping used was fine dirt well tamped onto the powder and completely filling both tunnel and drift for a distance of 10 ft. back from the charges. Bulkheads of rock were placed at intervals of 10 ft. throughout the length of the tunnel in order to tamp its roof solid. At the drift portal and locking against the opposite wall of the tunnel a bulkhead of heavy green oak timbers was placed and well tamped. The dirt and rock tamping was then carried forward to within 20 ft. of the tunnel portal. If the ground had been conglomerate instead of exceedingly hard granite, the total dynamite primers used would have been 500 lbs. instead of 5,400 lbs., for in conglomerate the percussive action of dynamite would be waste energy, inasmuch as the action required would be heaving and the sole use of dynamite in the charge would be to control the rate of detonation of the nitro-glycerine content of the "Champion" powder. In the hard granite at Morena a rending as well as heaving action was required to produce adequate results, hence the use of a comparatively large quantity of dynamite.

During the loading and handling of the large quantities of powder it was customary to require that all the men engaged surrender matches and smoking materials, and the men in the pit remove their shoes and wrap their feet in sacking. The circuit was tested frequently at the tunnel portal during tamping in order that possible breaks be detected and repaired before burying the wires too deeply. The battery to be used was tested up to full strength before using. Light was furnished by candle lanterns securely wired to pegs driven into bore holes in the sides of the tunnel and drifts.

The loading of the charge was supervised by Mr. J. S. Molony, Resident Engineer, and Messrs. A. H. Crane and H. F. Smith, Agents for the Du Pont Powder Company.

The Melville and Macalpine Speed Reduction Gear for Marine Steam Turbines.

We described in our issue of Oct. 27 the new gearing invented by Admiral Geo. W. Melville and his partner, Mr. John H. Macalpine, for use in connecting a high-speed steam turbine to the screw propeller of a vessel. As our readers will recall, the object of this device is to enable both the turbine and the propeller to be so designed as to operate at the best efficiency. In the present marine turbine installations in which the turbine is on the same shaft as the propeller, a compromise has to be made. At one end of the shaft the turbine has to be of much larger diameter and with slower speed revolution than would be otherwise desirable. On the other end the propeller has to be made of such small diameter and fine pitch that its efficiency runs away down, losing power first through the high velocity of the water which it drives astern and second through the skin friction of the hub and blades running at high velocity.

The doubts which we expressed as to the safety of the gearing under the shocks of sea-service were met by the statements of its designers in our issue of Dec. 9, showing that the gear has a large margin of strength over the shafts which it connects. With this matter cleared away, the new gearing becomes unquestionably of the highest importance as an advance in marine engineering, and indeed in mechanical engineering generally, for it is not at all improbable that this high-speed gearing may not only bring the steam turbine into universal use for vessel propulsion, but into other fields from which it has hitherto been excluded by its high rotative speed.

We have been favored with advance sheets of a pamphlet in which Mr. Geo. Westinghouse, who has been the leader in promoting the work by Messrs. Melville and Macalpine which resulted in this invention, relates the history of the development. The pamphlet also contains the results of tests on the 6,000-HP. experimental gear, which has been constructed at the Westinghouse Machine Co.'s works at East Pittsburg. We reprint from this pamphlet the following interesting statement as to the origin of the invention:

About six years ago, Rear-Admiral George W. Melville, ex-Engineer in Chief, U. S. Navy, and Mr. John H. Macalpine, Consulting Engineer, undertook at my request a thorough investigation of the then existing status of the steam turbine as applied to the propulsion of ships, and the probabilities of its becoming the ultimate successor of the highly developed types of reciprocating engines commonly used for that purpose.

The data gathered in the course of the investigation and the conclusions drawn therefrom, were embodied in an exhaustive and interesting report which was delivered to me by its authors in May, 1904.

This report was not of a very encouraging nature, but in the few years that have intervened, there have been developments which effect a radical change in the situation existing at that time. The accompanying description of certain interesting and important work that has been carried out by The Westinghouse Machine Co. at East Pittsburg, Pa., under the direction of Messrs. Melville and Macalpine gives one a vivid impression of the rapidity with which history is made in the engineering art.

The most significant statement in the report of May, 1904, is to be found in the conclusion. It reads as follows:

If one could devise a means of reconciling, in a practical manner, the necessary high speed of revolution of the turbine with the comparatively low rate of revolution required by an efficient propeller, the problem would be solved, and the turbine would practically wipe out the reciprocating engine for the propulsion of ships. The solution of this problem would be a stroke of great genius.

There could be no greater tribute to the far-seeing and well-balanced judgment of the authors of this report, than the fact that nearly five years later this identical sentiment was publicly voiced not only by Mr. James Denny, of Denny & Brothers, Dumbarton, Scotland, the oldest and most experienced builders of turbine propelled vessels in the world, and the most consistent advocates of the system, but also by the Honorable Charles Algernon Parsons himself, by whose brilliant creative imagination, the basic idea of the modern marine turbine was conceived, and by whose courageous initiative it was made an accomplished fact.

The parallelism of thought is so unusually striking that I quote the utterances of Mr. Parsons and Mr. Denny verbatim, as reported. Mr. Parsons in concluding his James Watt Anniversary lecture delivered at Greenock, Scotland, on Jan. 15 of the present year, said:

We might naturally speculate as to the future and inquire if there is a possibility of the turbine being constructed to run more slowly, and without loss of economy or whether the propeller can be modified to allow of higher speeds of revolution. Or, again, may a solution be found in reverting to some description of gearing—not the primitive wooden spur gearing of half a century ago, but to steel gearing cut by modern machinery with extreme accuracy and running in an oil bath, helical tooth gearing or chain gearing, or again, some form of electrical or hydraulic gearing? These are questions which are receiving attention in some quarters at the present time, and if a satisfactory solution can be found, then the field of the turbine at sea will be further extended.

Mr. Denny, in his presidential address to the Institution of Marine Engineers in Britain on Oct. 5, 1908, said:

It has frequently been suggested that if some inspired engineer would evolve a system of gearing that would be lasting and reliable, not too noisy, and would not absorb in friction more than say, 10% of the power, turbine engines would be capable of application to any speed of vessel, and to any size of propeller; you would then have a high speed turbine and a low speed propeller, which is the ideal condition for marine propulsion.

The problem first recognized by Messrs. Melville and Macalpine, and the importance of which has since been admitted by Mr. Denny and Mr. Parsons, has been solved. It has been solved by Messrs. Melville and Macalpine themselves, so that by one of the amusing freaks of fate, the compliment to the then unknown solver, implied in the last sentence of the paragraph quoted from their report of May, 1904, comes back to rest upon its unsuspecting makers.

The desired end has been accomplished by means of a reduction gear, which makes possible any reasonable speed ratio between the turbine shaft and the propeller shaft. It was no easy task to design a system of gearing that will operate quietly and without destructive wear at the speeds common to steam turbines of the highest efficiency, and at the same time be capable of transmitting thousands of horse-power. The details of the design that has proven itself capable of fulfilling these requirements, are fully set forth in the able and comprehensive article reprinted from "Engineering," Sept. 17, 1909 [Eng. News, Oct. 21], which is based on data supplied by Messrs. Melville and Macalpine. However, a few additional words of a nontechnical character, generally descriptive of the gear, and indicative of its significance as a factor in marine construction will not be out of place.

The teeth of the gears are helical, that is to say they do not run straight across the face of the wheel parallel to the axis as in the case of ordinary spur gears, but they are cut in the form of a steep spiral, like an exaggerated screw thread. This construction allows the teeth to roll into contact without shock or jar. If there were only a single gear on each shaft, this helical form of tooth would cause an objectionable end thrust. As the gears must be very wide to transmit the enormous powers required in marine service two gears, each of half the required width, are placed on each shaft, with the spirals of the teeth running in opposite directions. In this way the end thrust due to the obliquity of the teeth is completely balanced. With a pair of wide-faced gears with straight teeth, it is hardly possible to cut the teeth with such accuracy and to align the shafts so perfectly as to get uniform contact throughout the entire length. Even if it were possible to secure the requisite degree of accuracy at the outset, it could not be permanently maintained on account of the natural wear of the bearings. In general, the conditions are such that a rigidly confined set of gears such as are common for moderate speeds and powers, is altogether inadmissible.

In the design which has proven its sufficiency under severe and exhaustive tests, the smaller gear or pinion is mounted in what the inventors call a "floating frame." The frame which carries the bearings for the pinion is a heavy steel casting supported only at a single point midway between the bearings. This support is flexible so that the frame is free to oscillate in a vertical plane passing through the axis of the pinion, but is held securely against motion in any other direction. Furthermore, the pinion is free to move endwise in its bearings. Any tendency of the teeth to bear harder at one end of the gear than the other would tend to unbalance the respective end thrusts due to the right and left hand spirals of the teeth; but as the pinion cannot present any resistance to unbalanced end thrust, it constantly adjusts itself in the direction of its axis to the position corresponding to equilibrium between the opposing forces. This means that the tooth contact pressures are always automatically equalized.

If there are any minute irregularities in the spacing of the teeth, which would tend to make the contact harder at one point than another in any part of the revolu-

tion, this tendency is defeated by the floating frame, the position of which about its central support or fulcrum is controlled solely by the pressures of the teeth of the pinion against the teeth of the large gear. Naturally, the floating frame always yields under the slightest tendency of an unbalanced contact pressure in such a way as to transfer the smallest increment of unbalancing pressure to another section of the gear that in the absence of the floating frame would be less inclined to take its full share of the stress. In short, the gears are self-adjusting to relieve and equalize all abnormal strains, and are consequently independent of the small inaccuracies that are impossible to eliminate in the best commercial manufacturing operations.

The probable efficiency of the gear was naturally the most anxious question, as the operating conditions were so wholly unprecedented that there were no existing data to enable one to even hazard an estimate. The effect of a low efficiency would be more serious than a mere impairment of the economic performance of the installation, as the transmission losses would manifest themselves in heating and destructive wear that would mean hopeless failure for the scheme in its entirety.

In order to definitely settle the question as to the practicability of the gear, it was necessary to devise methods, and to design and construct special appliances for testing it under all of the conditions of load and speed that would probably obtain in actual commercial service. The dynamometer for applying and measuring the loads to which the gear was subjected, will, I trust, be considered sufficiently novel and interesting to warrant the extended description that will be found in another part of this publication.

Considering the important bearing of the question of efficiency on the ultimate success or failure of the gear, it is peculiarly gratifying to have found by repeated trial and careful measurement, that the transmission loss hoped for by Mr. Denny, has been divided by seven. To be exact, the efficiency surpasses the more than satisfactory figure of 98.5%, a result that is without doubt inseparably connected with the flexibility and self-adjusting character of the apparatus.

It is needless to say that the gear is enclosed in a substantial casing, that adequate means are provided for its constant and efficient lubrication, and that the ingeniously designed connections between the gear and the turbine effectually prevent the self-adjusting movements of the pinion from communicating any longitudinal or transverse stresses to the turbine shaft.

Mr. Westinghouse then proceeds to compare the present propelling machinery of the Cunard steamships "Mauretania" and "Lusitania," with the equipment which would be possible in these vessels if the speed reducing gear were used. These vessels are now equipped with steam turbines developing 70,000 HP. He estimates the propeller efficiency at 55% and the steam consumption of the turbines at 14.5 lbs. per shaft horsepower per hour. With the high-speed turbines and low-speed propellers made possible by the Melville-Macalpine gearing, a propeller efficiency of at least 65% would be reached and a steam consumption in the turbines of not over 11 lbs. per horsepower hour. This gain in efficiency would reduce the coal consumption for the voyage by 35% and only 45,000 HP. of boilers instead of 70,000 would be required to make the present speed. The great saving in weight and space by the reduced boiler capacity and coal carried for the voyage would be of enormous value for cargo.

On the other hand, if greater speed is deemed more desirable, the space and weight saved could be utilized either for additional power or the hull could be much smaller, thus reducing the resistance. Mr. Westinghouse continues as follows:

The "Mauretania" and "Lusitania" have two high pressure and two low pressure turbines, and two reversing turbines working on four shafts. According to the best information obtainable the high pressure turbines have each 128 double rows of blades, and the low pressure turbines 60 double rows each. The total length of the blading exclusive of the relatively small amount in the reversing turbines, is about 115 miles, and the total surface area of the blades is considerably more than three-quarters of an acre, or equal to the sail area of a large ship.

By using the reduction gear, the same total propulsive power could be installed in three turbines. There is nothing problematical about this statement, as turbines developing the requisite power, and of the same general design as would in connection with the reduction gear be suited to marine work, have been operating successfully for a long time, and their power and economy are now matters of authentic record. Each turbine would have only 51 double rows of blades, a total in the three turbines of 153, or only 25 in excess of the number of rows in one of the high pressure turbines alone in the present installations on board the Cunard flyers. The total length of the blading in the three high speed turbines would be less than six per cent. of that in the low speed turbines.

Each shaft would be driven by a complete and independent self-contained turbine, and each shaft would have its own reversing turbine so that the entire screw equipment would be available for backing instead of only one-half of it, as is the case in the present arrangement.

However much the new system promises for express steamers in the mercantile marine, it has vastly more important advantages as applied to naval vessels. The express steamer normally runs at its highest speed, and this is the condition for maximum turbine efficiency. This is especially true in the case of turbines connected directly to the propeller shaft, for the reason that as outlined before, the peripheral speeds and number of rows of blades are at best below the requirements of efficient design, and any dropping below the maximum speed accentuates the bad effect of this deficiency

On the other hand, in the case of a battleship or a cruiser, maximum speed is only an emergency condition. The normal cruising speed is only about 60% of the maximum speed, and requires perhaps less than 25% of the maximum power. It is at the cruising speed that turbine propelled naval vessels have shown to disadvantage as compared with vessels propelled by the best types of reciprocating engines. By reason of the more liberal blading that is possible in a high speed turbine, its economic performance is less sensitive to departures from maximum rotative speed, than is that of the low speed turbine. Furthermore, as the entire expansion of the steam takes place in a single turbine, the total power may be distributed conveniently among three entirely independent units, driving one central and two wing propellers. The central unit alone will suffice for ordinary cruising speeds, and can be operated always at somewhere near its most economical conditions of working.

In naval service, the ability to start the turbines when cold, and quickly bring them to full speed may often be of the very highest importance. With turbines directly connected to the propeller shafts, the lengths and diameters of the rotors and casings are such that in order to prevent serious distortion from unequal heating and expansion, it has been found necessary in practice to bring all of the turbine machinery to the normal working temperature before it may safely be set in motion. I have been informed by those having charge of turbine machinery on a large battleship, that the preliminary warming often requires some hours.

In the double-flow turbine which it is proposed to use with the Melville and Macalpine gearing, the smaller dimensions consequent on the higher speeds gives a sturdier construction in which the tendency to distortion is reduced to a negligible minimum; and an elastic self-adjusting mounting for the stationary blades, easily removable for examination without unseating the rotor, compensates for any inequality in the expansion of the rotor and the casing, and effectually prevents the stripping of blades even if there should be actual contact between the stationary blades and the body of the rotor, or between the moving blades and the casing. With this construction, steam, even though it carries large quantities of water of condensation with it, may be admitted to cold turbines, and full speed obtained in less than a minute.

The United States Government has lately awarded contracts for two new battleships, to be equipped with steam turbines. These battleships are to have a speed of 20½ knots, which will require in round numbers 28,000 shaft horse-power. With 55% propeller efficiency the effective propelling power will be about 15,400 HP. With the 65% propeller efficiency that is easily possible with the reduction gear and a propeller at a lower speed of revolution, this same propelling power would require less than 24,000 HP. on the shaft. The average steam consumption guaranteed at full power is about 14½ lbs. per shaft horse-power. With the better steam economy of the high speed turbine, the boiler capacity required would be reduced fully one-third. With the same bunker capacity, the radius of action would be enormously increased, which is an advantage of incalculable value.

If the same boiler equipment as is now proposed were maintained, there would still be a saving in weight of over 250 tons, or approximately one-eighth of the total penalty weight of the machinery in each ship, resulting solely from the substitution of the high speed turbine and reduction gear for the more cumbersome slow speed direct connected machine. At the same time, by reason of the well known overload capacity of a liberally proportioned turbine, there would be available a surplus power of about 50%, which should make possible an emergency speed of nearly three knots in excess of that called for in the specifications.

Furthermore, the three independent shafts, each with its own self-contained turbines for going ahead and astern, would give the excellent manoeuvering qualities which are admittedly lacking in vessels fitted with the present conventional turbine equipment.

The certainty with which the floating-frame of the Melville and Macalpine reduction-gear operates to maintain an evenness of tooth-pressure and the limitation of the maximum pressure to 450 lbs. per in. of tooth-contact with a load of 6,000 HP., coupled with a large factor of safety, at once remove this invention from an experimental to a completely commercial apparatus.

I regard this invention as epoch-making in its importance. It has been my privilege to supply the material things which were needed to transform the creature of Messrs. Melville and Macalpine's imagination into an actual thing of iron and steel. The results achieved by the completed machine have fully justified my faith in its ultimate success.

A 6,000-HP. Hydraulic Absorption Dynamometer.

By H. E. LONGWELL.*

In order to carry out the tests to determine the capacity and efficiency of the experimental spur-wheel reduction-gear for high speed turbines, it was necessary to provide some form of brake or dynamometer that would be capable of absorbing a continuous output of 6,000 effective HP.

A brake of this capacity was in its way as entirely unprecedented as the gear itself. In any form of mechanical brake, the energy is transformed into heat, and in dealing with such large powers as were contemplated, the problem of carrying away the heat generated becomes a very serious one. When one recalls that the quantity of heat generated by the absorption of one horsepower is 2,545 B.T.U. per hour, or about

Fig. 1. View of Hydraulic Brake for Testing Turbine Speed-Reduction Gear in Westinghouse Shops.

one-fifth that resulting from the combustion of a pound of coal, one is better able to comprehend the magnitude of the problem by making the simple calculation that shows the total quantity of heat to be dealt with, is practically that which would be generated in a furnace burning coal continuously at the rate of 1,200 lbs. per hour.

An ordinary band or "Prony" type of friction brake was entirely out of consideration, as the speed would limit the diameter of the brake wheel to six or seven feet, and its face would have to be not less than 30 ft. The difficulties involved in the construction, and the cooling of such a brake, and the maintenance of the proper tension on a brake band of this width are practically insurmountable.

Naturally the first thing to suggest itself was the use of an electric generator with a water rheostat for adjusting and maintaining the load. Such a generator would be cumbersome and expensive, the windage and electrical losses would vary with different loads and speeds, and there would always be an uncertainty as to the exactness of the allowances made for these losses. Neither are the most careful electrical measurements quite as satisfying and convincing as direct comparisons with the familiar force of gravity.

The idea of the electrical dynamometer was therefore abandoned because of the uncertainty that its indications would be sufficiently exact to enable the transmission loss in the gear to be determined with any reasonable degree of finality, as it was hoped that this loss would be very small, and possibly within the probable limits of accuracy of this method of measurement.

*Consulting Engineer, Westinghouse Machine Co., Pittsburg, Pa.

For a number of years the Westinghouse Machine Co. has successfully employed a form of hydraulic brake for measuring the power developed in the works tests made on all steam turbines manufactured by it. This form of brake consists of a rotor mounted on a shaft coupled to the shaft of the turbine, and rotating within a closed casing supported on journals through which the rotor shaft passes. The casing is held against turning by means of a radial arm bearing against a vertical strut, the lower end of which rests on an ordinary platform scale. Within the casing is a quantity of water, which quantity may be maintained constant at any desired amount by means of inlet and outlet pipes with adjustable controlling valves.

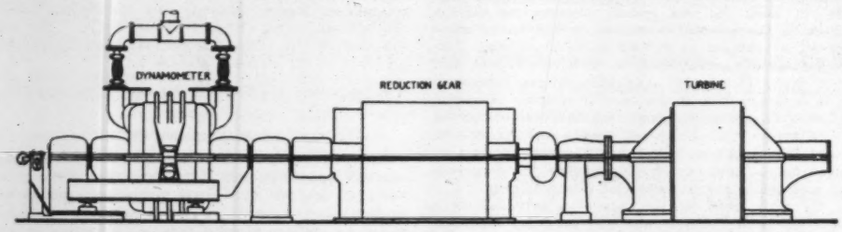


FIG. 2. DIAGRAM SHOWING ARRANGEMENT OF APPARATUS FOR TESTING.

The rotor has a series of vanes or teeth on its periphery which tend to impart a rotary motion to the water contained in the casing. The inner surface of the casing is provided with vanes or teeth which resist this tendency, and the result is a powerful braking action, the intensity of which can be regulated by the quantity of water in the casing. The resistance which the casing must offer to prevent its being rotated by the water striking its inwardly projecting vanes at high velocity is measured by the pressure exerted on the platform scale by the strut under the radius arm, and from this pressure, the effective length of the radius arm, and the number of revolutions per minute, the power is calculated in identically the same manner as in the case of an ordinary Prony or band brake. As a matter of course, the temperature of the water is quickly raised to the boiling point, and a considerable portion of it evaporates, and in the form of steam easily carries off the enormous quantities of heat generated. The amount of fresh water admitted to compensate for the quantity lost by evaporation and through the overflow pipes, is constantly adjusted by the attendant in such a way as to keep the scale at all times in perfect balance.

The successful brakes constructed on this principle had all been designed for high speeds, ranging from 750 r. p. m. for the largest, up to 4,000 or more for the smallest sizes. In order to adapt the same principle to a brake that should have the requisite capacity and stability at the lower speeds of the driven shaft of the reduction gear, the radically new design, of which a detailed description follows, was developed by Mr. Raymond N. Ehrhart of the Westinghouse Machine Company's engineering staff.

The line drawing (Fig. 2) shows the disposition and relative proportions of the several component parts.

Fig. 1 is a general view of the dynamometer, and the arrangements for weighing the load. On account of the heavy pressures to be dealt with, the resistance of the radius arm is not taken up directly on the platform of the scale, but is transmitted through a knife edge bearing to an I-beam, one end of which rests on a solid foundation and the other end on the platform of the scale. The I-beam also rests on knife edge bearings at either end, and forms a lever of such proportions that only one-fourth of the total stress comes on the scale. At the top of the dynamometer will be seen the flexible hose pipe connections for admitting the water to the interior of the casing.

Fig. 3 is a view of the interior of the upper half of the casing, and shows the stationary vanes which resist the impulse imparted to the water by the rotor. These vanes are inserted and supported in precisely the same manner as the blades in the cylinder of a steam turbine.

Figs. 4 and 5 are two views of the rotor, bladed with regular steam turbine blading sections, the rows on one side of the center being of what is called "right hand section" and on the opposite side of "left hand section."

The water enters the top half of the casing through ports on either side which register with the passages in the side of the rotor clearly shown in Fig. 4 just inside the rim. Through these passages the water is carried to the middle of the rim of the rotor and is discharged through the ports shown in Fig. 5 between the two innermost rows of blades.

With the aid of the diagram, Fig. 6, a developed cross section through the blades, the action that takes place will be readily understood. The moving blades are shown in solid and the stationary blades in cross-lined section. The water emerges with a whirling motion from the Port A, and immediately meets the broad central row of stationary vanes which check its angular velocity. It escapes to the right and left from the passages between the central row of stationary vanes and is picked up by the first rows of moving blades on either side. These moving blades again impart a high angular velocity to the water, and by reason of the curvature of their section project it into the adjacent rows of stationary vanes, where the velocity is again checked. This action is repeated as the water passes through the successive rows of moving and stationary blades, until it reaches the outermost rows of moving blades.

From these last rows of moving blades the water is projected into circumferential passages of semi-circular cross section in either end of the casing.

These passages are shown at B in Fig. 7, a partial cross sectional view through the rotor and casing. At intervals in these circumferential passages are baffles to

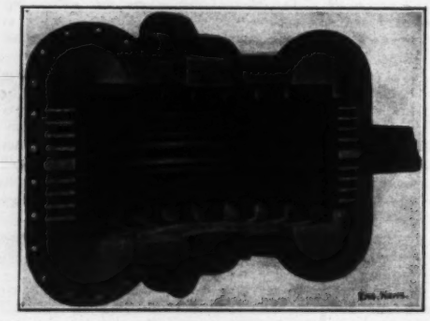


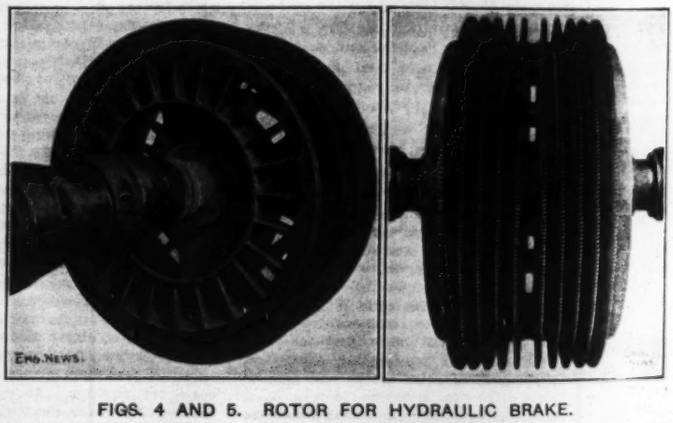
Fig. 3. Upper Half of Casing of Hydraulic Dynamometer, Showing Stationary Vanes.

again check the angular velocity of the water. These baffles are shown plainly in Fig. 3, inside view of upper half of casing. The passages in the casing re-direct the water into the rotor—or at least so much of it as has not been already evaporated—and the entire cycle of operation is repeated indefinitely.

Fig. 8 is a section through the assembled dynamometer. The passages through which the water enters are indicated by the letters C and C^1. D and D^1 are vents for the escape of the steam generated by the transformation of the mechanical energy into heat. It is not practicable to carry off all of the heat by evaporation alone, as the generation of 15,000 lbs. of steam per hour in the casing would cause such a violent boiling as to interfere with the stability of the braking action. Consequently the quantity of water admitted into the casing is considerably in excess of the quantity evaporated, and the surplus is discharged at boiling temperature through the passages E and E^1.

The dynamometer measures the output of the gear with the utmost precision, but in order to determine the transmission loss, it is imperative that the input should also be known. An extensive series of tests was carried out in which the power was measured by a dynamometer attached directly to the shaft of the turbine. It was found that for each speed and load, with a constant vacuum and with steam of uniform quality, there was a corresponding inlet steam pressure. By often repeated trials it was found that by reproducing any particular set of conditions of speed, inlet pressure and vacuum, the brake load could be predicted with unfailing accuracy. This fact being thoroughly established, it was only a matter of a long and tedious series of routine trials to calibrate the turbine for all the loads and speeds at which the plant was to be tested. As variation in the vacuum has the most serious influence on the power of a steam turbine, all other operating conditions remaining the same, the calibration tests were made with an abnormally poor vacuum, so as to allow more ample margin for control, than would be possible if it had been attempted to maintain a vacuum that would more nearly tax the capacity of the air pump.

The dynamometer, notwithstanding that it was an entirely new creation, has operated in the most gratifying manner as regards steadiness, sensitiveness, and capacity, and in general has creditably upheld its part in what is perhaps the most extensive laboratory experiment that has ever been undertaken and carried out by strictly private enterprise.



FIGS. 4 AND 5. ROTOR FOR HYDRAULIC BRAKE.

Tests of the Melville and Macalpine Experimental Reduction Gear.

When the Melville and Macalpine experimental reduction gear was first erected and started on Sept. 7, 1909, extensive preparations had been made to determine the efficiency of the apparatus on the assumption that there might be a transmission loss of at least 5%. After calculating the results of a few preliminary trials, it was found that the apparent efficiency was over 98% and this raised the perplexing question as to how to determine this unexpectedly small transmission loss with a satisfying degree of exactitude.

If the efficiency were only from 90 to 95%, its measurement, within reasonable limits of accuracy, would have been an easy matter. Rising as it unquestionably does, above 98½%, it will be readily understood that the problem requires a refinement of method, and a degree of painstaking care far beyond that which is usual in ordinary engineering investigations.

For the reason that the efficiency is so remarkable, it has been thought advisable to describe the methods employed and to tabulate the principal observations with a minuteness of detail that might, in many cases, be considered superfluous.

Naturally the first trials of the gear were made at very moderate speeds and loads, with frequent stops to examine the condition of the teeth and bearings. During the first few days the speed was gradually raised to 1,500 r.p.m. of the turbine shaft [equivalent to a speed of 5,500 ft. per minute on the pitch circle] and 300 revolutions of the gear shaft, and a load of over 6,000 brake HP. was carried. The load was limited only by the power of the turbine, as there were no indications that the ultimate safe capacity of the gear had from any standpoint been nearly approached.

On Saturday, Oct. 16, 1909, an endurance test at maximum load and speed was started at 3.15 p. m., and continued until 7.15 a. m. on the following Monday, or a total of 40 hours. This test was witnessed by Commander R. S. Griffin, U. S. N., and Lieutenant-Commander U. T. Holmes, U. S. N., specially delegated for this purpose by the Bureau of Steam Engineering of the United States Navy Department.

The load was applied by the hydraulic dynamometer described on the preceding pages. The radius arm of this dynamometer is 6½ ft., and the pressure exerted is transmitted to the platform scale through a lever having a ratio of approximately 1 to 4, as shown in Figs. 1 and 2. The precise distance between the knife edges on the lever being, however, 18 inches and $72^{29}/_{32}$ inches respectively, the effective length of the radius arm of the dynamometer is

$$\frac{6.5 \times 72.15625}{18} = 26.056 \text{ ft.}$$

The constant for one pound pressure on the scale and one revolution per minute is consequently

$$\frac{26.056 \times 2 \times 3.1416}{330000} = .0049612 \text{ HP.}$$

During this trial the following average conditions were maintained:

Gross weight on scale	4443.4 lbs.
Dead weight on scale	388. lbs.
Net weight on scale	4055.4 lbs.
Speed	300.6 r.p.m.
Brake horsepower	6048.

There was nothing in the operation of the gear to indicate that this load might not be carried indefinitely. It will be readily understood that a constant draft of 6,000 to 7,000 HP. on the boiler plant of an industrial establishment like the Westinghouse Machine Co. could not be long maintained without interfering with the regular operations of the company. As a consequence, the duration of an experiment of this nature and magnitude is necessarily limited to the period between noon on Saturday and the early morning of the following Monday, during which time all other activities are in a large measure suspended.

A continuous test of five or six days representing the time of an average transatlantic voyage would doubtless be of more popular interest, but it would be of no more real scientific value. When all the parts of the apparatus have once attained a maximum temperature which remains constant for a reasonable period, and providing that temperature is within the limits generally recognized as conservative, a condition has been established which is capable of being maintained indefinitely. No useful data could be obtained from a further prolongation of the trial, excepting the very probable development that as the wearing parts became polished and took on a better surface, the operation of the apparatus would improve. In the present instance the trial continued over 34 hours after the temperature conditions had become constant.

With the dynamometer above described, the measurement of the power output of the gear becomes a very simple matter. But to determine at the same time the effective power input, is an engineering problem that is more than a little out of the ordinary. If the gear were driven with a reciprocating engine, the natural procedure would be to measure the indicated horsepower, and either estimate or measure the friction of the engine, and thus obtain a correction which, when applied to the indicated horsepower, would give the effective power delivered to the gear.

There being no way in which to measure the indicated horsepower of a steam turbine, it became necessary to establish the exact brake horsepower in some other way. Happily, there is one characteristic of the steam turbine that makes it possible to calibrate any particular machine in such a way that its output in effective horsepower at any instant may be determined with greater accuracy than it is possible to determine even the indicated horsepower of a reciprocating engine. As long as the speed and exhaust pressure are maintained constant, the absolute inlet pressure of commercially dry steam, at any instant, is a very accurate measure of the brake horsepower the turbine is developing.

By substituting for the reduction gear, a dynamometer connected directly to the turbine shaft, and operating the turbine at a fixed speed, and with a constant vacuum in the exhaust pipe, we may determine the inlet pressures corresponding to different loads at this speed.

Plotting these observations on a diagram in which the ordinates represent absolute pressures per square inch, and the abscissas represent brake horsepowers, and drawing a line through the several points, we get a scale by means of which the horsepower corresponding to any inlet pressure may easily be read. This line is practically straight, so that readings made between the points representing actual observations, are quite dependable.

The diagram, Fig. 9, shows the calibration of the turbine used on these tests at 1,500 r.p.m with a vacuum of 22.78 ins., corrected to a barometric pressure of 30 ins.

The radius arm of the high speed hydraulic dynamometer used in calibrating the turbine is 48.375 ins. The constant per pound pressure on the scale is therefore

$$\frac{48.375 \times 2 \times 3.1416 \times 1500}{12 \times 33000} = 1.1513$$

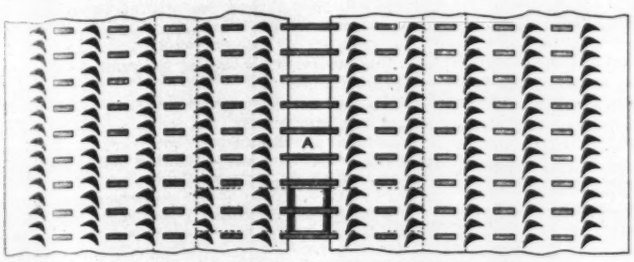


FIG. 6. BLADING OF HYDRAULIC BRAKE.

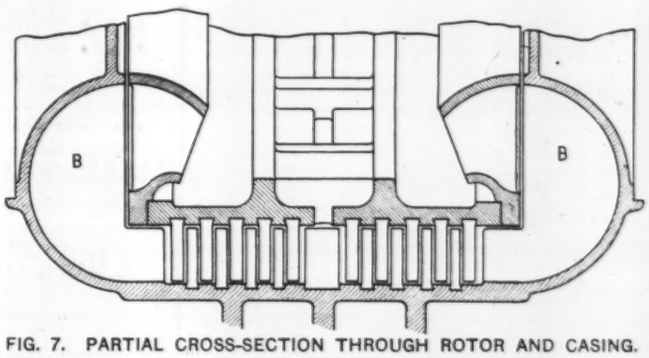


FIG. 7. PARTIAL CROSS-SECTION THROUGH ROTOR AND CASING.

Table I gives the observed absolute inlet pressures, loads on scale, and calculated brake horsepowers over a considerable range above and below 5,000 HP. From these observations and calculations, a calibration curve similar to that shown in Fig. 1, was drawn to a large scale so that small differences of loads and pressure could be read accurately.

With the reduction gear connected to the turbine, a number of observations were made of the absolute inlet pressures corresponding to practically the same range of

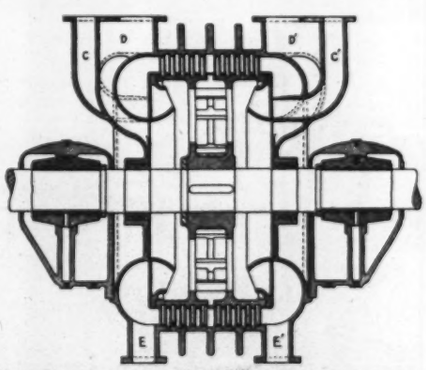


Fig. 8. Section of Assembled Dynamometer.

loads transmitted through the gear to the slow speed hydraulic dynamometer.

In these tests, as well as in the turbine calibrations, at every load before reading the inlet pressure, the speed of the turbine was brought exactly to 1,500 r. p. m. as indicated by a vibration tachometer, and the vacuum adjusted to exactly 22.78 ins. corrected to a barometric pressure of 30 ins. The vacuum was purposely carried abnormally low by bleeding a small quantity of air into the exhaust pipe. By means of a small valve in the air inlet pipe, the vacuum could be quickly and accurately adjusted to the arbitrary standard without its being necessary to make any change in the speed of the air pump or the quantity of the circulating water.

The gear and pinion having respectively 176 and 35 teeth, the speed of the driven shaft would be 298.3 r.p.m. The horsepower constant of the dynamometer is, as stated above, .0049612.

In Table II, column 1, are the observed absolute inlet pressures corresponding to the different loads transmitted through the gear as set down in column 5. In column 6 are given the horsepowers of the turbine alone corresponding to the same inlet pressures, as determined from the calibration curve. Obviously, the quantities in column 5 represent the power output of the gear, and those in column 6 represent the power input. The quantity in column 5, divided by the quantity standing against it in column 6, gives the efficiency as it appears in column 7.

While the efficiencies as calculated from these observations are consistent and uniform over the whole range of observations, the total transmission loss as shown, almost falls within the limit of the normal error that might reasonably be expected in measuring such large total quantities of power. And in spite of the fact that the greatest precautions were taken to insure accuracy, the readings being checked by several observers, and the gauges and scales being standardized before and after each trial, one would feel some hesitation in vouching for these efficiencies if there were no way of checking them. Fortunately, a satisfactory check is available.

The gear is lubricated by circulating a copious supply of oil under a head of about 10 lbs., through the bearings, and through a spray which plays continuously on the teeth of the wheels. The transmission loss in the gear therefore appears as heat in the oil. The heated oil coming from the gear is passed through a cooler which is very like a surface condenser with cold water circulating through the tubes.

By measuring the quantity of oil circulated and noting the rise in temperature in passing through the gear, a close approximation of the number of British Thermal Units lost per hour in friction is obtainable.

At a load of 5088 HP. delivered by the gear, 591 lbs. of oil were circulated per minute, with an average rise in temperature of 9.86° F. The specific heat of this oil is 0.47, and consequently the total heat absorbed per hour is $591 \times 0.47 \times 60 = 164208$ B.T.U.

As 2545 B.T.U. per hour is the equivalent of a horsepower, the total heat accounted for in the oil is

$$\frac{164208}{2545} = 64.17 \text{ B.HP.}$$

The brake horse-power being 5088, and 64.17 horsepower being accounted for by the heat in the oil, the efficiency by this method of calculation would be

$$\frac{5088}{5088 + 64.17} = 98.75\%$$

This figure is probably a little too high, as there is an indeterminate small quantity of heat radiated from the gear casing and from the oil piping that has not been accounted for. Even if this were 20% of that accounted for, which is most improbable, the efficiency indicated would still be 98.5%.

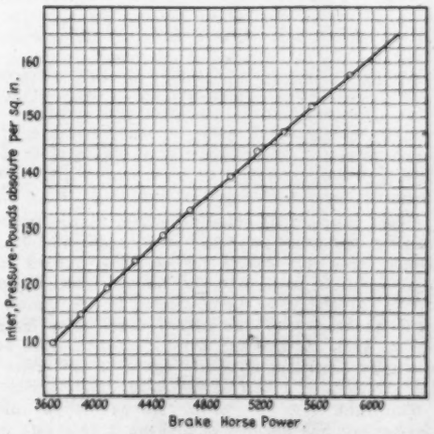


Fig. 9. Calibration of Turbine used in Gear Tests.

Giving due weight to both methods of measurement, and considering the closeness of agreement between them, it is quite evident that at approximately 5,000 HP., with the turbine running at 1,500 r.p.m., the efficiency of the gear is more than 98.5%.

TABLE I.

Inlet pressure absolute.	Gross weight on scale.	Dead weight on scale.	Net weight on scale.	B.HP.
109.6	3585	385	3200	3675
114.8	3755	385	3370	3880
119.3	3925	385	3540	4076
124.3	4095	385	3710	4271
128.8	4265	385	3880	4467
133.8	4435	385	4050	4663
139.3	4690	385	4305	4956
143.8	4860	385	4475	5152
147.3	5030	385	4645	5348
151.8	5200	385	4815	5543
157.8	5455	385	5070	5837

TABLE II.

Inlet pressure absolute.	Gross weight on scale.	Dead weight on scale.	Net weight on scale.	B.HP. delivered by gear.	B.HP. of turbine from calibration curve.	Efficiency.
111.8	2900	388	2512	3712	3771	98.7
122.3	3200	388	2812	4156	4197	99.0
132.3	3480	388	3092	4576	4623	98.9
142.3	3791	388	3403	5036	5108	98.7
152.3	4100	388	3712	5486	5567	98.5
162.3	4400	388	4012	5927	6067	98.7

Less elaborate and extensive determinations show an efficiency of 98% at a load of 3,096 HP. and 1,000 r.p.m. of the turbine, and 95% at a load of only 824 HP. and 750 r.p.m. of the turbine.

Efficiencies of High Speed Westinghouse Speed Turbines.

The Melville and Macalpine reduction gear, as has already been fully explained, permits the use of high speed turbines, the proportions of which have been developed to produce extraordinary results.

A Westinghouse Combination Double Flow turbine is about to be tested which is capable of developing 22,000 HP. with 175 lbs. steam pressure and 28 ins. vacuum, and it is estimated that the steam consumption will be about 10 lbs. per brake HP. hour. The principal dimensions are as follows:

Length over all	19 ft. 8 ins.
Height	9 ft. 0 ins.
Width	9 ft. 0 ins.
Weight	110,000 lbs.
Weight per horsepower developed	5 lbs.
Speed	1,800 r.p.m.

This particular machine is designed for land work, and in a modification of the general design to make it especially adaptable for marine propulsion, the weight could be materially reduced.

The following authentic tests lately made on turbines built by the Westinghouse Machine Co. show that under the conditions of steam pressure, superheat and vacuum as specified by the United States Navy Department for the battleships "Delaware," "North Dakota," "Utah," etc., a shaft horsepower can be developed on less than 11 lbs. of steam per hour.

(1) Westinghouse Combination Double Flow Turbine, No. 563, at the Williamsburg power station of the Transit Development Co., Brooklyn, Speed 750 r.p.m.:

Steam pressure at throttle	203.4 lbs.
Superheat	80.1° F.
Vacuum, referred to 30" barometer	28.6 ins.
Load	13,384.0 KW.
Steam per kilowatt-hour	14.4 lbs.
Efficiency of generator	98.0%
Windage	2.0%
Equivalent brake horsepower	18,620.0
Steam per brake horsepower hour	10.3 lbs.

(2) Westinghouse Parsons Turbine No. 253 at the Waterside power station of the New York Edison Co., speed 750 r.p.m.

Steam pressure at throttle	177.6 lbs.
Superheat	96.0° F.
Vacuum, referred to 30" barometer	27.3 ins.
Load	9,830.5 KW.
Steam per kilowatt-hour	15.18 lbs.
Efficiency of generator	98%
Windage	2.%
Equivalent brake horsepower	13,700.0
Steam per brake horsepower hour	10.89 lbs.

A Ball-Expansion Stud Rivet.

The ingenious device shown in the accompanying sectional illustration affords a means of securely fastening a rivet into a blind hole. The stud rivet is drilled axially and chamfered at one end before driving, as shown at A in the figure. A hard steel ball of diameter slightly greater than that of the hole in the rivet is dropped into the hole which the rivet must fill. When the rivet is driven in, the ball is forced into the hollow end, as shown at B, and expands it tightly into the hole. By rightly proportioning the diameter of the ball to that of the hole drilled in the rivet, a very satisfactory grip is obtained.

The stud rivets can be turned out easily and cheaply on an automatic screw machine, and steel balls discarded for slight defects by manufacturers of ball bearings are sufficient for this device and can be obtained at low cost.

In the "American Machinist" for Dec. 9, 1909, was published the following table of proportions:

	In.	In.	In.
Diameter of stud	5/16	3/4	5/8
Depth of hole	1/2	1 1/2	1 1/4
Size of ball	1/4	5/16	9/32
Diameter of center bore	1/10	5/32	1/4
Depth of center bore	3/32	5/32	7/32

These proportions were developed in the practice of the Link Belt Co., of Philadelphia, Pa., which uses this device for securing flanges to the sprockets used with the Renold silent chain drive. According to the statement in the "American Machinist" of the above date, tests have shown that the average grip of a 5/8-in. stud of the type described is nearly equal to the breaking strength of a bolt of the same diameter.

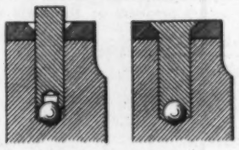
The Link Belt Co. owns the patent on this device, but has decided to present it as a gift to the mechanical world. The letter containing this announcement is reprinted below:

American Machinist,
505 Pearl Street,
New York.

Referring to Mr. Hill's inquiry as to the efficiency of the ball expanded drive stud he saw in use in this shop would say that we find these about as strong as bolts of the same diameter—they are in to stay. Yes, it is patented.

This drive stud, or blind rivet, has been of great use to us and saved us many dollars. We own the patent on it. It is something we might sell or otherwise exploit, but this is not our business.

We would like to present this patent to the mechanical world and will do so here and now through the "American Machinist."



A Ball-Expanding Stud Rivet for Blind Holes.

We give it for the benefit of any and all who desire to use it and agree never to claim any rights, royalties or remunerations for it.

We hope that it will be as valuable to other machinery makers, as it has been to us.

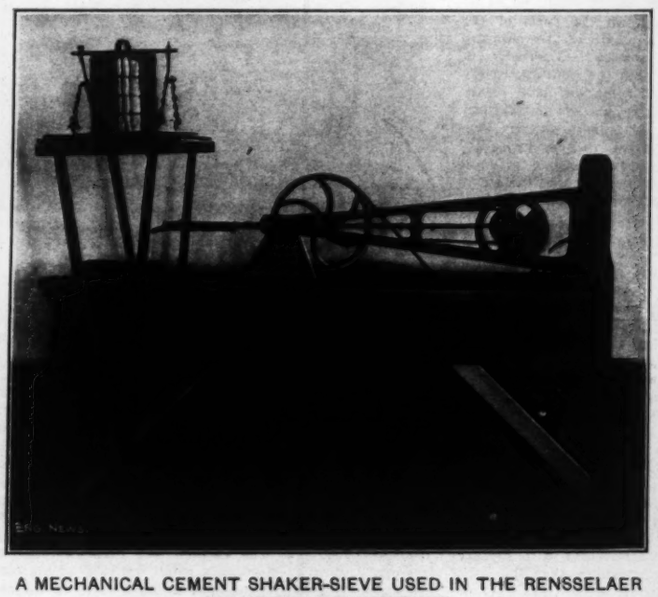
LINK BELT CO.,
James M. Dodge, President.

A Mechanical Cement Shaker-Sieve.

By T. R. LAWSON,* M. Am. Soc. C. E.

The Committee on Uniform Tests of Cement of the American Society of Civil Engineers, in its report to the Society on Jan. 20, 1909, advocates the use of the hand method of sieving cement in the test for fineness, giving as a reason "that after careful investigation, the conclusion has been reached that mechanical sieving is not practicable or as efficient as hand work."

In large laboratories where many different samples of cement are being tested at one time, to follow the above recommendation becomes very tedious and consumes a great deal of time. This has been avoided in the laboratory of the Rensselaer Polytechnic Institute by the use of a mechanical shaker which greatly reduces the time and is also as efficient as hand shaking.



A MECHANICAL CEMENT SHAKER-SIEVE USED IN THE RENSSELAER POLYTECHNIC INSTITUTE.
(Devised by Prof. T. R. Lawson.)

The shaker, shown in the accompanying half-tone, consists of a nest of sieves of 50, 74, 100, and 200-mesh, respectively, with pan and cover, rigidly attached to a slide which rests upon a frame to which it is loosely fastened by means of two bolts with nuts and washers projecting from the frame vertically through two slotted holes in the slide. The slotted holes are at an angle of 30° with the direction of the longitudinal motion of the machine. The frame moves in the arc of a vertical circle, carrying the slide with it. When the end of the stroke is reached, the inertia of the slide carries it forward and a lateral motion results, since the bolts serve as guides in the slotted holes. Before the bolts reach the end of the slots, the end of the slide comes in contact with a striking piece on the frame, which is now [illegible] its return stroke, thus producing a shock on the [illegible]ves and contents. The slide is then carried b[illegible]ard and the cycle repeated.

Power is applied by means of a 1-[illegible]P. motor attached to the eccentric as s[illegible] in the half-tone.

The charge of 50 grams of cement [illegible]laced in the top or 50-mesh sieve. Repeated [illegible]s show that it will begin to come through th[illegible]ttom or 200-mesh screen in 4 secs., and in [illegible] ins. the test will be completed to the extent th[illegible]ss than 0.1% will pass through by continuous [illegible]d shaking of one minute duration, as requir[illegible] by the Am. Soc. C. E. specifications. It is t[illegible] practice in this laboratory, however, to continu[illegible]e shaking for 5 mins.

*Professor of Rational and Technical Mechanics, Rensselaer Polytechnic Institute, Troy, N. Y.

ON GOVERNOR'S ISLAND, N. Y., headquarters of the Department of The East, U. S. Army, and almost within a stone's throw of the business section of New York City, it is reported, has just been completed the installation of an electric lighting system for streets and buildings to supersede an antiquated system of kerosene lamps. High-tension alternating current is supplied, through a cable from Brooklyn, to a rotary-converter substation.

A centrifugal fire pump, run by a 125-HP. motor, has also been installed. This is to supply a high-pressure hydrant line and to supersede the island ferry whose pumps up to this time have furnished the only fire protection.

OPERATING COSTS OF THE MERSEY RAILWAY (England), running under the River Mersey and connecting Liverpool with Birkenhead, as a steam and an electric line, are given in a paper presented before the Institution of Civil Engineers (British), on Nov. 9, by Mr. J. Shaw. This road was opened in 1886, but the operation was difficult and expensive, and the line became unpopular. A direct-current, third-rail electric-traction system was installed in 1903. The line was, and is, operated 19½ hours a day with a peak load morning and evening. During steam working the peak was met by increasing the number of trains in service, and, under electric working, the peaks are met by increasing the number of cars per train, keeping the interval between the trains constant throughout the day.

Now for heavy traffic the trains have four or five cars, a motor-car at each end. After the heavy service is over, the trains are divided, one motor-car and one trailer being used for each train unit.

To compare the costs of steam and electric operation, three years' records for each system were used. With electric traction 1 lb. of fuel, costing 8s. 9d. ($2.10) per ton, moves 1 ton of load 2.29 miles at an average speed of 22¼ mi. per hr.; whereas, with steam, the same weight of fuel, costing 16s. ($3.84) per ton, moved the same load 2.21 miles at an average speed of 17¾ mi. per hr. The effect on the permanent way has been to reduce the cost of maintenance per ton-mile from 0.0208d. (0.0416 ct.) to 0.0089d. (0.0178 ct.), or by 0.012d. (0.024 ct.) per ton-mile. The average rolling load over the track before the rails require renewal is increased from 32 million tons to 47½ million tons. The substitution of electrically driven pumps for the hydraulic lifts has decreased the cost per lift-mile from 85.2d ($1.704) to 30.1d. ($0.602), a decrease of 55.1d. ($1.102) per lift-mile.

The general costs per ton-mile were found decreased, as follows: (1) Total operating and maintenance of locomotive and engineering departments, from 0.238d. (0.476 ct.) to 0.152d. (0.304 ct.), a decrease of 0.086d. (0.172 ct.). (2) Total costs of the railway, including general charges, etc. (exclusive of interest on additional capital for electrification), from 0.344d. (0.688 ct.) to 0.24d. (0.48 ct.), a decrease of 0.104d. (0.208 ct.). (3) Including cost of extra capital invested in changing to electric traction, this figure of 0.344d. (0.688 ct.) per ton-mile has been reduced to 0.2928d. (0.5856 ct.). The average speed, including stops, has been increased from 15.6 to 19.9 mi. per hr., and the number of ton-miles from 43 to 67 millions.

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The heavy vote against a 25-year extension to street railway franchises which still have 16 years to run, in Kansas City on Dec. 16, is encouraging. The majority against the proposition was about 7,100 in a total vote of 30,400, which latter figure, we understand, approached quite near the registration. This large majority seems all the more remarkable when it is understood that as an inducement to grant the franchise extension the Metropolitan Street Railway Co. offered, virtually, a 4-ct. fare with universal transfers.

Aside from unwillingness to vote away street and attendant privileges so long in advance, it is reported that many voters felt that the company would, sooner or later, find some way to evade the lower-fare and transfer provisions of the proposed franchise. This is not at all surprising, in view of recent action of street railway authorities in New York and Philadelphia. We take it, however, that the people of Kansas City were more influenced by the belief that there was no good and sufficient reason why they should extend a franchise so long in advance of its expiration.

The company is reported as being quite doubtful as to its future and as to the character of the service it can render its patrons, in view of the negative results of the election. It states that the franchise extension was necessary in order to enable it to raise "money to pay maturing bonds, build extensions, buy new cars," etc., and that it "frankly so stated to the people of Kansas City." Frankness is good, but assuming all this to be true, for the purpose of argument, does it not show something wrong in the past or present management of the company? The declaration is, in effect, an assertion that the company cannot meet its obligations to its creditors, on the one hand, nor to its present and prospective patrons, on the other, without securing and then capitalizing an extension to a franchise that still has 16 years to run. Evidently the voters of Kansas City were not convinced that such was the case. Probably many of them were of the opinion that a good part of this franchise-extension capitalization would go into the pockets of insiders and at the same time be added to the watered stock on which street-car riders would be expected to pay dividends. Possibly the people of Kansas City may have to wait 16 years before they get 4-ct. fares, but at any rate they have not sold their children's birthright for a mess of pottage. If they have the intelligence and determination shown in the recent election campaign and victory they will yet secure all that is legitimately due them in both fare reduction and improved service. Before 16 years are passed we trust that Missouri and at least the majority of other states will have public-service commissions to control street railway and other franchise companies in the interests of both investors and patrons. This is already partly true in Massachusetts, New York and Wisconsin, although there remains something to be done in them as regards the regulation of fares and transfers.

The House of Representatives, before the holiday recess, passed with very little opposition the Esch Bill, requiring full reports of railway accidents to be made to the Interstate Commerce Commission.

Whatever may be done regarding the much-discussed question of giving to the Interstate Commerce Commission a larger measure of control over railway rates, it is practically certain that sooner or later, and very likely at the present session of Congress, it will be given full authority to supervise railway operations with respect to safety. The entering wedge toward this was driven in when the Commission, at the outset of its work, undertook to collect statistics of railway accidents. Another step in the same direction was taken when the Commission established an inspection bureau to secure the enforcement of the laws governing the use of car couplers and other appliances for the safety of trainmen. Still another move was the creation in 1907, in accordance with a joint resolution by Congress, of the Block Signal and Train Control Board.

Probably the idea of Congress in establishing this Board was that it would be able to select from some of the numerous inventions which are all the time being brought to public notice, some scheme or schemes which would prove a panacea for the prevention of railroad collisions. Those familiar with actual conditions of railway operation had, of course, no such expectations; but it was fully recognized that such a board, properly constituted, might do a highly useful work for the public and for the railway companies by systematically investigating all new devices of promise and encouraging any that seemed likely to bring about greater safety in railway operation.

The Second Annual Report of the Train Control Board, just issued, shows that during its two years of work no less than 835 different devices designed to enhance the safety of railway operation have been submitted to it. Out of this large number, only about two dozen have been found to possess sufficient merit that the Board might proceed to test them, if the owners of the invention should have them installed in regular railway operation. Only one device, the Rowell Potter automatic stop, however, has reached the stage of actual test.

The thing of most interest, however, is that the work of this Board is developing on much broader lines than was contemplated in its original organization. It has investigated during the past year not only devices in connection with signaling, but also in connection with locomotive ashpans, which come under the cognizance of the Interstate Commission on Jan. 1, and also new inventions in air brakes, automatic air-brake hose connections, sectional car axles, and a number of track devices, including even the effect of titanium as an ingredient in steel rails.

It is admittedly a long distance from the original purpose for which the Interstate Commerce Commission was established, to the supervision over details of railway rolling-stock, track, and structures, such as has now been actually undertaken by the Block Signal Board. The departure, however, appears to deserve commendation rather than criticism. The investigations of the Board, if carried on with impartiality and with technical ability, result to the benefit of the railway companies. The Board is in fact supplementing the work of the Safety Appliance Committees of the American Railway Association. That Association's committees, while they have the great advantage of intimate familiarity with railway operations, have the large disadvantage of lack of time to devote to the technical details involved. It is true that the Association might have done years ago just the work that the Interstate Commerce Commission through its Train Control Board is now doing. There were, however, admittedly, considerable difficulties in the way of the railways taking up this work for themselves. Now that it is being taken up for them by a Federal bureau, we trust the railway companies will not permit prejudice to interfere with the adoption of any practical measures which the Federal bureau may bring forward.

As some of our readers may recall, we have at various times criticised the method by which New York City has attempted to formulate a new building code by placing the work in the hands of a large commission, having in its membership representatives of all the various trades and professions affected. The code which was reported by the recent building code commission was vetoed by the Mayor, after being roundly condemned in various public hearings for the favoritism to certain interests with which, apparently, certain sections of the code were drafted.

To add insult to injury, however, the framers of that remarkable building code have rendered bills to the city for fees of $10,000 each for their valuable expert labors. This makes about $170,000 which the city is expected to pay for a building code which has been rejected and has probably no chance of adoption. The original bill was even larger than this, for a number of city officials were included in the commission and they also rendered bills for $10,000 apiece. The city's law department, however, ruled that additional compensation to those already receiving salaries from the city, would be illegal, and the Board of Aldermen has contented itself with approving the bills of the unofficial members of the commission.

There is also a previous bill outstanding against the city for work done by an earlier commission which also drafted a building code that was not adopted, that bill being, it is stated, for about $100,000. Up to date, therefore, New York has incurred an obligation of over a quarter of a million dollars in the effort to obtain a new building code—which admittedly is greatly needed—and has nothing to show for the expenditure except a danger averted.

It should be said in fairness, perhaps, that undoubtedly a number of the members of the building code commission did a large amount of honest expert work in formulating the proposed code, and are probably fairly entitled to payment therefor. The real difficulty was that the commission was made up of so large a number of members that the voice of the men of real technical ability was wholly lost.

The proper way to formulate a building code is not to go out with a drag-net and make up a huge legislative body to attempt the work; but to entrust the task to a small body of high-class experts. Men should be selected of such professional standing that they can be relied upon to draft a code solely in the public interest and without any admixture of graft or favoritism. It should be possible in that way to obtain an up-to-date code, and at a cost trifling in comparison with the huge bill which is now presented to the city.

Every engineer old enough to look back two or three decades must be impressed with the rapid specialization that has taken place, during that period in engineering and the allied arts and sciences. This is a matter of which the general public has comparatively little

comprehension. They regard an engineer as an engineer, an architect as an architect, and a chemist as a chemist. The extent to which the field of chemistry has become specialized is well indicated by the program before us of the meeting of the American Chemical Society held this week at Boston. The society holds one or two general sessions at its meetings, but most of the work is done by sections and divisions, and these are enumerated in the program as follows: Division of Agricultural and Food Chemistry, Section of Biological Chemistry, Section of India Rubber Chemistry, Division of Industrial Chemists and Chemical Engineers, Division of Organic Chemistry, Division of Fertilizer Chemistry, Division of Physical and Inorganic Chemistry, Division of Pharmaceutical Chemistry, and Chemical Education Section.

"No attention can be paid to anonymous communications." One would suppose that this standing rule of all reputable publications would be well known at this day by all intelligent men; yet Engineering News frequently receives letters which are signed by fictitious names. If the writers of such letters would imagine themselves in the place of the publisher, they would readily perceive the necessity of the cast-iron rule above quoted and the reasons why we cannot publish such letters nor any information they contain. We receive frequently letters containing items of news for publication where it seems evident that the writer omitted to sign his name merely from modesty. He did not reflect that without an authoritative signature, the news lacks all authority. Such items would not be published by a newspaper, and surely not by a technical journal, which aims at accuracy and reliability.

In this connection a word of advice may be of service to those of our readers who forward personal or business items. Not infrequently we receive an item for our Personal department accompanied by an offer of payment for its insertion "if payment is necessary." It may not be wholly needless, therefore, to say in this place that our "Personal" news column is conducted for the benefit of our readers solely, and that items of interest to the readers are always welcomed. That this department is read and appreciated is evidenced by testimony we have received from some of our older readers who have told us that the "Personal" page is the one they first turn to when they receive their paper.

The excellence and interest of that department depends more on the readers than on the editors. We wish to present each week in that department a record of the important business and professional changes affecting engineers of standing which have occurred during the week, with suitable obituary notices of those who have passed away. The department is not conducted to advertise the business of any engineer or engineers, and we endeavor to exclude such items as are mere records of the ordinary professional engagements of consulting engineers. But when an engineer is appointed to an important position or changes his business or location, the news is of interest to all his circle of friends and is well worth publication.

The editors, however, must rely for most of their information as to these important changes affecting members of the profession upon the engineers themselves. While direct acknowledgment of such items is impossible, hearty appreciation is here expressed of the pains which many engineers take to send us prompt news of important changes affecting themselves or their associates.

The Telephone-Telegraph Consolidation and Public Control.

The recent consolidation of the dominant telephone and telegraph interests of the country is a step in the right direction, but a step that emphasizes the long-existent need for national and state control of both services. Given such control in adequate measure and it would be highly advantageous to all concerned if the consolidation were carried two steps further, so as to include the single competing telegraph company and also the various "independent" telephone companies. By thus bringing the entire telegraph and telephone service of the country into one system a material increase in efficiency of service might be secured with an actual, or at least relative, decrease in cost—relative, that is, on considering the increased potential volume and value of service.

It has not yet been demonstrated in definite detail just what the economy and convenience of joint control of the telephone and telegraph service will be to the public. Certain advantages seem obvious: particularly those incident to making the telephone supplementary to the telegraph, and each complementary to the other; economies in line construction; feasibility of more rapid extension of underground wire service; and general relief of pressure upon aerial and sub-surface wire space in cities.

The benefits of consolidation would be greater in the telephone than in the telegraph service. Relatively few people are inconvenienced, save through higher rates, by the existence of two telegraph companies, but "two books to consult, two bells to ring and two bills to pay" are a nuisance to every one affected, besides being wasteful of time and money.

Even though the continued rates for two telephone services should be lower than was the charge for one service alone prior to competition, that state of affairs is not likely to continue indefinitely. If it should, it only goes to show the need for public regulation to make impossible the high rates that originally prevailed and to make unnecessary a duplication of plant in order to bring the rates to a more reasonable level.

Coming back now to the need for public regulation of telephone and telegraph companies. We have already intimated that recent consolidations have increased rather than created a need for public regulation. Further consolidation would make the need all the more apparent. Moreover, although the public has been deluded if not deceived as to the value of competition in all lines of public-service industry there is no question, but that the more the possibility of competition is reduced the greater is the need for public regulation.

Until within the past two years or so there was practically no regulation of either telephone or telegraph companies. The corporation tax law passed at the last session of Congress may prove to be the opening wedge for national regulation, but that is conjectural. A single state, so far as we know, has yet attempted to regulate telegraph companies. That state is Massachusetts, which recently gave the State Highway Commissioner considerable power over both telegraph and telephone companies. Wisconsin has given its Railroad Commission supervision over telephone and nearly all other public-service corporations save (if we are correctly informed) the telegraph.

We believe that further and ultimately complete consolidation of the telephone service of the country is desirable, and probably inevitable, and that the same bids fair to take place and is only in some lesser degree desirable for the telegraph. Quite regardless of consolidation, but at the same time accelerated by it, other states will join Massachusetts and Wisconsin in regulating telephone companies. Like regulation of the telegraph may not extend so rapidly, but it is likely to proceed faster if the telegraph and telephone are complementary to a marked degree. Regulation by the U. S. government will never be so essential in the case of "the electrical transmission of intelligence" as the Massachusetts authorities phrase it, as it is for the transportation of persons and things, but in some degree it, too, seems bound to come and should come within a few years.

Opposition to public regulation of public-service companies will of course continue in some quarters, but the broader-minded and more public-spirited investors in and managers of public-service corporations are not opposing regulation now as they did in the past.

If such regulation is to be extended as we believe it is bound to be, it will become more and more imperative to place the regulation in the control of men of the highest capacity and integrity, to give them such adequate compen[illegible] for their services as will remove them fr[illegible] p- tation and to give them adequate power [illegible] ds to secure the best engineering and othe[illegible] d services the country affords for carrying [illegible] r work. Under such conditions the public [illegible] ce corporations will welcome rather than opp[illegible] g- ulation. We believe that it is largely be[illegible] of the high character of the public-service c[illegible] is- sioners and their experts in Massachusett[illegible] ew York, Wisconsin and Michigan that the d[illegible] nd for such commissions in many states has [illegible] so insistent of late. The telephone-telegraph [illegible] ol- idation will increase the demand and wil[illegible] ke more apparent than ever the importance o[illegible] ut- ting on each commission the best men th[illegible] ate can afford.

A Remarkable Achievement in Transmitting Large Power at High Speed Through Toothed Gearing.

It seems probable that the writers of engineering history, looking back a few years hence, will set down the year 1909 as notable among other things for the development of a practical speed-reducing gear for use with marine steam turbines. In previous issues we have described this device, which was invented by Commodore Melville and his partner, Mr. John H. Macalpine, and has been brought into practical commercial form through the enterprise and financial backing of Mr. George Westinghouse. In this issue we supplement our previous articles on this device with a report of the detailed tests which have been made upon it, running under conditions closely approximating those to which it will be subjected on shipboard. An interesting feature in connection with these tests was the design and construction of what is doubtless the largest water brake ever constructed, in order to measure the power which the gear transmitted.

It may be of interest to some of our readers unfamiliar with the engineering principles involved, to explain why this invention, which is in its essential elements extremely simple—nothing but a pair of gear wheels connecting two parallel shafts—should be so important and so necessary to the further development of the marine steam turbine. In order to understand this it is necessary, in the first place, to appreciate one foundation principle of vessel propulsion. This principle is that for efficient propulsion of any vessel, from a rowboat to a battle-ship, the volume of water driven backward by the propeller should be as large as possible.

In all propulsion of vessels (except by sails or by towing) the vessel is driven forward by pushing against the water and sending a current backward with an oar, a paddle, a wheel or a screw propeller. In every case, the push against the water to drive the vessel forward drives a certain amount of water backward. The total energy imparted to an oar, a paddle-wheel or a screw propeller may be divided into three parts: one part drives the vessel forward, another drives the water backward, and a third is absorbed in friction—partly that of the machine itself, and partly that of the water, which is churned and driven in other directions than the backward flow. In order to make the energy imparted to the stream of water sent astern as small as possible, we must send a large volume of water at low velocity, rather than a small volume at high velocity. This is the underlying reason why all the multitude of schemes for jet propulsion have proved failures in practice.

Of course, in the practical application of this physical fact to the design of screw propellers, the losses due to the skin friction of the propeller have to be borne in mind. A propeller of very large diameter would send a large volume of water astern, but it would lose an excessive amount in the skin friction of its blades moving through the water. It is very difficult to make a screw propeller which will work efficiently in the propulsion of very slow vessels—canal barges, for example. The propeller has to be of such small pitch that a large part of its energy goes to churning up the water.

For vessels of ordinary sea speeds, however, there is no difficulty in designing propellers of such a diameter and pitch that they will work efficiently at the speed of the vessel, provided the designer has a free hand; that is to say, provided he can fix the rotative speed of the propeller without respect to the engine which drives it. But with the steam turbine mounted directly on the screw shaft, the designer is forced to make a compromise. He has, on the one hand, to adopt a rotative speed much higher than is desirable for efficient action of the screw; he has, on the other hand, to be satisfied with a rotative speed much lower than would be desirable to build an efficient and compact steam turbine. It is for this reason that marine designers, ever since the advent of the steam turbine, have been desirous of finding some means of placing the turbine and the propeller on independent shafts, connected by speed-reducing gearing, so that both machines could work under conditions of greatest efficiency.

Now, about the simplest and most ordinary way of connecting two parallel shafts together so that one will drive the other, with a speed reduction between the two, is by toothed gearing. It is exactly this simple solution that has been worked out to apparent success by the engineers associated with Mr. Westinghouse. The ingenuity lies not in the means adopted, since toothed gears of the type which are here used date back to an early period in mechanical engineering. The ingenuity and the notable achievement in mechanical engineering is in planning the details of construction of these gears in such a manner as to overcome the defects and hindrances which have hitherto prevented the use of gear wheels for any such speeds and any such large powers as are here transmitted.

According to all traditions of mechanical engineering, toothed gear wheels are only suitable for use at low speeds. By this tradition, it is safe to say, mechanical designers of the present day, even, consider themselves bound. But the fact is, when one stops to consider, that this tradition is actually based on the fact that the toothed gear of our grandfathers was made with crude and imperfect tools, and with a resultant inaccuracy that caused noise and inefficiency and rapid wear.

Many of our readers may recall that when De Laval first developed his pioneer steam turbine, running at 20,000 to 25,000 r. p. m., he had to invent a speed-reduction gear through which it could drive machinery permitting only ordinary rotative speed. The De Laval gear, however, was of trifling size and power—a mere toy, in fact, compared with the 6,000-HP. gear which has been built at the Westinghouse shops.

This new gear is an object-lesson in mechanical engineering, not alone because of the high speed and large power which is demonstrated to be practicable for tooth-gear transmission, but because of the astonishingly high efficiency which it has shown to be possible. In all work in machine design, when power has to be transmitted from one shaft to another, a frictional loss has always to be allowed for by the designer, whether the transmission be by belts, sprocket chains, rope drive or gearing. Probably 5% to 15% of the power transmitted would be a conservative estimate of the power which is absorbed in every such drive.

In designing the Melville-Macalpine reducing gear, it was originally expected that a loss of at least 5% would be experienced; and it is little short of a revelation of new possibilities in mechanical engineering that the loss in this transmission should fall to the astonishingly low figure of barely 1½%. The explanation for this high efficiency is doubtless to be found, first in the mechanical accuracy with which the gears are constructed, and second in the ingenious manner by which they are mounted so that uniform bearing of the teeth is secured; but third, and most important, in the high speed at which the gears are operated.

It has been long on record in the literature of mechanical engineering that the efficiency of gear transmission increases with the speeds at which it is driven. Experiments reported by Wilfred Lewis to the American Society of Mechanical Engineers in 1885 showed efficiencies approaching 98% for ordinary wheel spur gearing driven at speeds very moderate compared with those now shown to be possible. The Lewis experiments also showed that the efficiency steadily increased with the number of revolutions per minute up to a speed of about 200 r. p. m.

It has seemed to us that this demonstration of the possibilities of high speed and high efficiency in toothed gear transmission is worth the particular attention of the engineering profession. It may lead to important advances in mechanical engineering in other fields than the marine steam turbine.

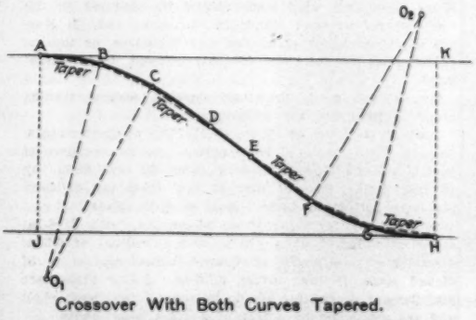
Mr. Westinghouse, in his interesting discussion of the new invention printed elsewhere in this issue, lays especial stress on the possibilities which the new gear opens in the application of the turbine to the propulsion of naval vessels and high-speed passenger steamers. This, however, is a field where the turbine is already being applied, although under the inefficient conditions which we have above pointed out. At present, however, the steam turbine is wholly inapplicable to the great mass of steam vessels on the high seas—the vessels which run at ordinary speeds, the freight carriers, and the tramp steamers. If, however, this new device should fulfil in practice the promise shown in its preliminary tests, there is every reason to suppose that it would mean the retirement of the reciprocating steam engine from ocean service and the adoption of the turbine in its place. This change will be accelerated by the recent improvements in the efficiency and reliability of steam turbines, whereby they have become better able to compete with the highly developed marine steam engine.

It is quite within the possibilities, also, that this speed-reducing gear may lead to new applications of the turbine on shore. Up to the present time the turbine manufacturers have been fully occupied in supplying the demand for steam turbines for driving electric generators. In this field, the high rotative speed of the turbine is of great advantage, since it greatly facilitates the design of the generator and cheapens its cost. There are numerous other fields, however, where slow-speed machinery is to be driven, where the steam engine still holds first place and is likely to retain it unless the turbine can be made applicable by some such reducing gear as that which has now been produced.

LETTERS TO THE EDITOR.

Locating a Tapered Reverse Curve Between Parallel Tangents.

Sir: Referring to the article by Mr. W. C. Willard on "The Southern Pacific Taper Curve Tables and Their Use," which appears in your issue of Oct. 28, 1909, and particularly to the crossover problem "C" on pages 463 and 464: I understand how this problem may be easily solved by finding the distance O_1 O_2 between centers, but would be pleased to see a complete solution of the traverse A B C D E F G H under the conditions specified by Mr. Willard.



Crossover With Both Curves Tapered.

[Reproduced from Fig. 9, p. 464, of W. C. Willard's article, "The Southern Pacific Taper Curve Tables and Their Use with the Traverse Method," Eng. News, Oct. 28, 1909.]

Yours respectfully, H. M. Lull.

East Auburn, Cal., Nov. 17, 1909.

Sir: Referring to the article on the Southern Pacific Taper by Mr. W. C. Willard in your issue of October 28, the solution of the "crossover between parallel tracks" problem as outlined by Mr. Willard is not clear and the undersigned questions his application of the traverse method to effect the solution.

The writer begs permission to advise that he has solved problems of a similar nature, but always found it necessary to first compute the distance O_1 O_2 between centers of curves, and the direction of this line with respect to the parallel tracks. One can readily see that the length of the reversing tangent DE, tapers and degrees of curves being specified or given, the distance O_1 O_2 is a constant, regardless of the distance between parallel tracks and the angles Δ_1 and Δ_2.

Furthermore the problem as stated is one never encountered in practice, at least not on the Southern Pacific, as that railroad always inserts its standard turnouts at either end of the crossover and not the taper curves as Mr. Willard shows. The taper curves have no place in ordinary crossover or Y tracks, where the trains as a matter of course are not running at such a speed as to require such an amount of superelevation of the outer rails of the curves as would make the use of taper or easement curves either appropriate or necessary.

Yours respectfully,

C. M. Kurtz.

234 Iowa St., San Francisco, Cal., Nov. 19, 1909.

[The solution of the crossover problem by the instructions contained in Mr. Willard's article is readily possible, though apparently it is neither short nor simple. To test the application we have taken a specific problem and worked it out by the method of the article. In abbreviated form it is as follows:

Problem.—Spacing of parallel tracks, 150 ft.
Length of tangent, 400 ft.
Curve 1, 4° curve; R_1 = 1,432.69 ft.
Curve 2, 5° curve; R_2 = 1,146.28 ft.
Both curves spiraled by Taper Table 2, giving a curve changing degree 1° in 30 ft.

From the table (in Mr. Willard's article),
Total curvature of initial taper of Curve 1, 1° 48′
both tapers of Curve 1, 3° 36′
initial taper of Curve 2, 3° 00′
both tapers of Curve 2, 6° 00′.

Then
$\Delta_1 + 3° 36' = \Delta_2 + 6° 00'$, or $\Delta_2 = \Delta_1 - 2° 24'$.

Taking the straight track as north, the bearing of intermediate tangent is $\Delta_1 + 3° 36'$.

The latitudes and departures of the tapers from their initial tangents are obtained from the tables (in Mr. Willard's article). The latitude and departure of the central curve from its own initial tangent are $R \sin \Delta$ and $R (1 - \cos \Delta)$, which can be projected on the adopted coordinates. For example, Curve 1 gives latitude and departure:

$$\text{Latitude} = 1{,}432.69 \ (\cos 1° 48' \sin \Delta_1 + \sin 1° 48' \cos \Delta_1 - \sin 1° 48').$$
$$\text{Departure} = 1{,}432.69 \ (\sin 1° 48' \sin \Delta_1 - \cos 1° 48' \cos \Delta_1 + \cos 1° 48').$$

The tabular latitude and departure of the final taper of Curve 1 are similarly projected, giving

$$\text{Latitude} = 89.99 \cos (\Delta_1 + 3° 36') + 1.10 \sin (\Delta_1 + 3° 36').$$
$$= (89.99 \cos 3° 36' + 1.10 \sin 3° 36') \cos \Delta_1. - (89.99 \sin 3° 36' - 1.10 \cos 3° 36') \sin \Delta_1.$$
$$\text{Departure} = 89.99 \sin (\Delta_1 + 3° 36') - 1.10 \cos (\Delta_1 + 3° 36').$$
$$= (89.99 \sin 3° 36' - 1.10 \cos 3° 36') \cos \Delta_1. + (89.99 \cos 3° 36' + 1.10 \sin 3° 36') \sin \Delta_1.$$

Writing down the latitudes and departures of all the courses in this way and adding gives the total departure between tangents:

$$\text{Departure} = 2{,}580.15 + 666.00 \sin \Delta_1 - 2{,}543.34 \cos \Delta_1.$$

This must equal the spacing of tangents. The expression is in the form

$$2{,}580.15 + K \sin (\Delta_1 - a).$$

Computing a from the coefficients of $\sin \Delta_1$ and $\cos \Delta_1$ gives $a = 75° 19' 33''$,

$$\text{and } \sin (\Delta_1 - a) = \frac{150 - 2{,}580.15}{[3.419806]},$$

or $\Delta_1 - a = -67° 34' 3''$.

Then $\Delta_1 = 7° 45' 30''$, barring error, as we have not checked over our computations. The central

angle of Curve 2 is 7° 45′ 30″ — 2° 24′ = 5° 21′ 30″.

It is evident that the method is feasible, but also that it is tedious and clumsy. The cases in which ordinary crossovers require to be spiraled are few, as Mr. Kurtz points out. It should be noted, however, that the article quoted the examples to show the adaptability of the traverse method, in conjunction with latitude and departure tables of a complete set of easement curves, to a wide range of calculations.—Ed]

Lack of Uniformity in Results of Cement Tests.

Sir: Mr. Saurbrey's article on "A Comparison of Reports of Tests of the Same Cement by Various Laboratories," and the editorial comments upon the same subject, in Engineering News, Dec. 9, 1909, are of interest to all who are concerned with the testing of hydraulic cement. The troubles noted are probably almost universal. The writer has had occasion to do some testing, and in order that he might avoid gross errors in the interpretation of his results, it has been his custom to make companion tests, using for the purpose a cement upon which he had already made a considerable number of tests and with the properties of which he was familiar. This practice has often proved to be of considerable benefit, particularly in the case of tests upon a brand of cement with which he was unfamiliar. For this reason the writer has been of the opinion that it would be an excellent thing for some organization, such as the American Society for Testing Materials, to provide for the establishment of a standard cement. Such a cement might perhaps be made by using a mixture of a number of brands of first-class cement. Upon this standard cement careful and complete tests would be made by a laboratory designated for the purpose, and the results of these tests would be furnished with each shipment. If such a cement were obtainable, specifications could be written requiring companion tests to be made, and requiring the results for the cement in question to be corrected according to a given scale, by comparison of the results of the test upon the standard cement with the results obtained by the standardizing laboratory.

There are many things which would need to be carefully considered in establishing such a method, but the writer offers the suggestion in the hope that those who are interested will offer their opinions upon the matter.

Referring to Mr. Saurbrey's results, the writer wishes to call attention to the following items, all of which accord with his own observation. (1) It is nearly impossible for two persons to obtain the same numerical results for tests upon a given sample of cement. (2) The results obtained by any one person, who has had some experience in testing cement, are generally in accordance with other results obtained by the same observer. (3) There is likely to be a greater variation in the results of 24-hr. neat tensile tests than in the results of neat tensile tests for longer periods of time. (4) With the exception of the 24-hr. neat tests, there is likely to be a greater variation in the results of 1:3 mortar tests than in the results of neat tensile tests.

If item 2 is correct, the use of companion tests should make it possible to obtain a reliable report upon any cement, since the acceptance or rejection of such a sample would be to a large extent dependent upon the work of the standardizing laboratory.

With reference to item 3, it would seem to be undesirable to place too much dependence upon the results of 24-hr. tensile tests. If the results of 24-hr. tests are to be of much service it is necessary to attend carefully to the temperatures of the cement, the water used, and the moist closet, since upon these depends to a large extent the rapidity with which the setting and hardening occurs. The methods of testing which are at present recommended by the American Society of Civil Engineers provide for the temperature of the water used in mixing and for the temperature of the water used in storing the briquettes, but nothing is said concerning the temperature of the cement or the temperature of the moist closet. It is possible that some of the discordance in the results for short time tensile tests and for time of set tests could be avoided by more rigid requirements relative to the conditions of temperature.

With reference to item 4, it is probable that the principal cause of variation in the results of 1:3 mortar tensile tests is the personal equation in molding the briquettes. The introduction of the use of plastic mortar for neat tensile tests has done much to overcome great variations in the molding of neat briquettes, but there is likely to be considerable difference in the compactness with which two observers will mold sand briquettes. The variation which may be due to this one cause is well shown by some results which the writer has at hand. Mixtures of 1:3 mortar were made with each of a number of different brands of cement. Of each mixture a number of briquettes were made by hand molding, by use of an Olsen press, and by use of a Böhmé hammer. The mean tensile strength for each set of briquettes is shown by the following table:

TABLE SHOWING VARIATION IN TENSILE STRENGTH OF 1:3 MORTAR DUE TO VARIATION IN MOLDING.

Brand of cement.	Hand molded.	Olsen press.	Böhmé hammer.
A.....	197	181	433
B.....	255	164	509
C.....	107	128	235
D.....	157	145	370

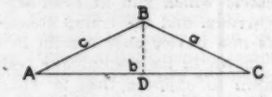
The above results were obtained by students in the course of class work and are perhaps not as reliable as the results of more experienced observers, but they are quite sufficient to illustrate the point in question.

Yours truly,
L. A. Waterbury,
Professor of Civil Engineering,
University of Arizona.

Tucson, Ariz., Dec. 15, 1909.

A Simple Solution for Oblique Triangles When Two Sides and the Included Angle are Known.

Sir: The letter from Mr. F. W. Rizer in your issue of Dec. 2, 1909, prompts me to submit the following method for the solution of a triangle when two sides and the included angle are known. It is, I think, simpler than the method by tangent formula.



In the triangle shown in the accompanying sketch, suppose the angle A and the adjacent sides b and c are known. The problem is to find the value of one of the other angles and of the side a.

Drop a perpendicular from the vertex B to the side b. Call the foot of this perpendicular D, and call its length x.

Then

$$x = c \sin A$$
$$AD = c \cos A$$
$$CD = b - AD; \text{ or if } A > 90°, CD = b + AD$$
$$\frac{x}{CD} = \tan C$$
$$a = x \div \sin C.$$

F. S. Foote, Jr.

Montclair, N. J., Dec. 6, 1909.

Notes and Queries.

An interesting special problem in structures is submitted by Mr. Rex C. Wilson, of Coatesville, Pa. It concerns the calculation of conical roofs of steel tanks such as are used for water, oil, etc. The conical tops are made of sector plates lapped and single-riveted on the radial joints, and flanged at the outer circumference to turn down inside the shell plates, to which they are usually single-riveted. The middle of the top is generally made of a circular plate dished to spherical contour, which laps over the inner ends of the sector plates and is riveted to them. In some cases this is replaced by a vent dome, similar to a steam dome on locomotive boiler, which of course is heavier than a simple dished plate.

It is desirable to make the conical top self-supporting, i. e., requiring no interior columns or trussing, and preferably dispensing with stiffening ribs on the sector plates. For any given case it is desired to know (1) What snow and wind loads should be assumed on the roof, where the tank stands in the open; and (2) How are the stresses for given rise and thickness, or the required rise and thickness for safe stresses, to be calculated.

Mr. Wilson sends drawings showing several specific cases to illustrate the problem:

Tank 15 ft. diameter, ⅝-in. shell. Top of eight sectors, flanged down inside of shell plates. Sectors support at center a cylindrical plate-iron dome 32 ins. diam. by 16 ins. high. Rise of top, 12 ins. from top of shell plates to bottom of dome. Roof of ⅜-in. plate.

Tank 24 by 30 ft., roof of 24 sectors, with 5/16-in. spherically dished plate (10 ft. 8 ins. radius) of 60-in. diameter of rivet circle, at center. Rise of roof to top of dished plate, 18 ins.; metal, 3/16-in. Sector plates are not flanged down into shell, but lap 2 ins. over shell and are connected by a ring of 2 × 2 × ¼-in. angle.

Tank 38 ft. diam. by 12 ft. high to top of shell. Roof of 16 sectors, ⅜-in. metal. Center is a dished or coned ring 24 ins. inside diameter and 93 ins. on outer rivet-circle, carrying a low plate-iron dome 24 ins. diameter.

Tank 45 ft. diam. by 20 ft. high to top of shell. Roof, 20 sectors, with 93¾-in. spherical plate at center. Rise to top of dished plate, 6 ft. 3 ins. Shell ½-in. plate; roof ⅜-in. plate, flanged down inside of shell.

Formulas for bending moments and buckling stress in such roofs would be of interest.

A Report on Smoke Reduction in Cleveland.

Damage by smoke in the city of Cleveland is estimated at $5,000,000 to $6,000,000 annually by a committee on Smoke Prevention of the Cleveland Chamber of Commerce, of which Mr. E. P. Roberts, M. Am. Soc. M. E., is chairman. In arriving at this estimate the loss from smoke was decided under several heads as follows:

1. The domestic loss, or losses to the occupants of residences and their occupants.
2. Loss to retail stores.
3. Loss to wholesale stores.
4. Loss to offices, banks, etc.
5. Loss to manufacturers.
6. Loss to hotels.
7. Loss to libraries, museums and similar institutions.
8. Loss to hospitals and similar institutions.
9. Effect on health of persons, animals and plants.

No estimate was made of the financial loss due to injuries to health and to vegetation; but the following interesting computation of the effect of sulphuric acid was made:

In connection with the Ninth classification, the committee finds it impossible to make any definite statement. To what extent the soot itself is injurious to animal and plant life varies with conditions, though frequently it is very injurious. To a large extent it is not primarily the soot which is objectionable, but the fact that it acts as a vehicle to transport the sulphuric acid which results from the combustion of coal. Professor Mabery of Case School of Applied Science stated that the coal used in Cleveland contains from 1 to 2% sulphur, and taking 1½% as a fair average, he estimated that the amount of sulphur in the coal yearly consumed in this city is 75,000 tons, which is converted into sulphuric acid and exists in the atmosphere in that form. The weight of sulphuric acid derived from this sulphur is 230,000 tons a year, or 630 tons for every day in the year. It works its way into buildings, into books and fabrics, and is exceedingly destructive.

There is no one but may recognize the effects of this acid upon vegetable life. The blackening of tree trunks and the decay of foliage by soot, which always carries sulphuric acid, are apparent on every hand. It covers the leaves and stems with a thin layer of tarry substance, which clogs the pores and effectually prevents the complete process of plant respiration. Sulphuric acid is highly destructive to the forms of organic compounds of which vegetation is composed, and it accumulates in the deposited soot in such quantities as to be very injurious. In complete combustion with no escape of soot, the natural conditions of the atmosphere will prevent any undesirable effect from the products given off.

The committee summarized its conclusions as follows:

Estimated direct material loss to Cleveland from smoke nuisance, $6,000,000 annually. Average annual loss per individual, $12; per family, $44.

Committee considers reduction of 20% of smoke nuisance in next two years to be feasible. This reduction would equal reduction of city taxes, exclusive of amount for state purposes, by over 20%, and the entire elimination of the smoke nuisance would be equivalent to practical elimination of city taxes.

Cost of city smoke department, $7,500. If existence of department resulted in elimination of twelve-hundredths of one per cent. of nuisance, existence of department is justified.

A law making possible enforcement of smoke preventive methods should be secured, and to aid in passage of such law, active public opinion should be aroused, and cooperation of civic bodies in other Ohio cities should be enlisted.

A GOLD DREDGING RECORD was made at Bear Creek in the vicinity of Dawson, Yukon, this year by Mr. Joseph W. Boyle, Manager of the Canadian Klondike Mining Co. Under his operation, a dredge started digging at 11 p. m., May 9, 1909, and worked till 7 a. m., Nov. 20, 1909, a period of 194 days and 8 hours. During that period, 681,616 cu. yds. of material were handled, at a cost for actual operation of dredge and power plant, including maintenance and repairs, of 15 cts. per cu. yd. This gives an average of 3,538 cu. yds. per day throughout the season. The total lost time was 308¾ hours, or 7.9% of the total running time. The dredge with which this record was established was made by the Marion Steam Shovel Co., Marion, Ohio, and was equipped with steam piping along the working parts, and under the sluicing tables and at other points to prevent freezing. With this equipment it is possible to operate effectively at temperatures as low as 20° F. below zero. The dredge had a bucket capacity of 7½ cu. yds.

A PANAMA AND PACIFIC EXHIBITION is proposed to be held at San Francisco in 1915, to celebrate the completion of the Panama Canal. The preliminary organization has opened offices at 1033 Merchants' Exchange Building, San Francisco.

Some Notes on the Separation of Solids from Sewage and Waste Liquors.*

By JAMES P. NORRINGTON.

In the fifth report of the Royal Commission on Sewage Disposal it is clearly demonstrated that of all the processes for the treatment of sewage which are commonly in use today that which costs the least in upkeep has for its preliminary process *quiescent settlement* without chemicals. On the other hand, the initial cost of the tanks required is higher than all but one of the five preliminary processes compared in the report. The area of filter however, to follow the preliminary quiescent

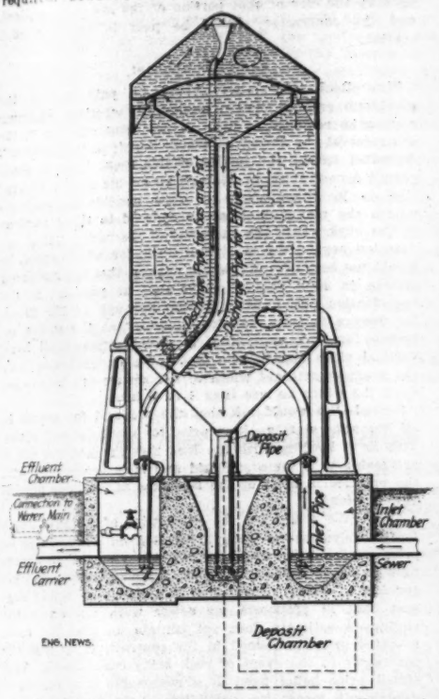


Fig. 1. The Sewage Kessel, a German Type of Sewage Sedimentation Tank.

settlement tanks is found, as a rule, to be considerably less than with most of the other processes; in other words, the greater the percentage of suspended solids removed, the larger is the volume of sewage that can be treated on the same area of filter; in fact, throughout the report the elimination of the suspended matter from sewage before allowing the flow to pass on to the filters or into a stream, or by way of storm-water overflows, is considered a matter of the highest importance. Any means, therefore, which can be successfully and economically adopted for the removal of the suspended matter are well worth our consideration; if, at the same time, they facilitate the handling of the solid matter or sludge, that will also be of advantage.

The object of this paper is to bring before your notice one or two arrangements for attaining these ends which are being successfully worked on the continent and in this country.

The first of these, like many other good as well as indifferent things, comes from Germany, and is known there as the kessel, the name probably being derived from the boiler-like shape of the apparatus. Its main feature is a vertical cylinder with an inverted cone-shaped bottom, and a cone-shaped or domed top. This is fixed on wrought-iron or brick supports above the level of the flow of sewage to be treated. The apparatus is so arranged that the flow is siphoned through this cylinder with a loss of two or three inches only in the level of the sewer. This is effected as follows: [Fig. 1.]

A manhole, or chamber, is constructed at the point on the sewer from which the sewage is taken, the floor of which is a foot or more below the invert of the sewer at this point. Into this the short leg of the siphon is brought and finishes below the invert of the sewer, so that it is always trapped.

On the opposite side of the kessel a corresponding manhole or chamber is provided to receive the long leg of the siphon, which is trapped in a similar manner.

The invert of the outfall from this second chamber is kept two or three inches below the invert of the sewer as it enters the first manhole, to ensure siphonic action.

Directly below the kessel a third chamber is provided, and into this a third pipe or leg (known as the deposit pipe) is brought from the bottom of the cone. This also is arranged so that the foot of the pipe or leg is trapped.

Reference to the accompanying diagram will make this clear, and it will be seen that the short leg of the siphon, or inlet pipe, as it is called in the diagram, passes through the cone-shaped bottom of the kessel and finishes inside same immediately over the center of the inverted cone, the end of the pipe being shaped so as to deflect the heavier solids in that direction. The long leg of the siphon, or discharge pipe for effluent, is also carried through the cone-shaped bottom of the kessel up the center of same to near the top of the cylindrical portion, where it finishes in a covered inverted cone, the greatest diameter of which approximates the internal diameter of the cylinder of the kessel. The inlet to this cone is through a narrow slot extending the whole circumference of same, immediately below the cover. You will also notice in the diagram that there is a fourth pipe marked "discharge pipe for gas and fat," which passes through the cone-shaped bottom, and finishes with a small cone-shaped mouth directly below the center of the cone or dome-shaped top.

For easier manipulation all four of these pipes are fitted with valves. To ensure siphonic action through the kessel it is necessary to first fill it with water, and for this purpose a connection to the water main is provided to one or other of the before-mentioned legs. In the diagram this is shown connected with the discharge pipe for effluent, or long leg of the siphon.

The action of the apparatus is as follows:

The large cylinder or kessel having first been filled with water, and the three chambers into which the legs of the siphons are conducted filled sufficiently to trap the legs, and the valves in the legs opened, siphonic action at once commences, and the sewage finding its way into the inlet chamber passes up into the kessel. The shape of the inlet pipe as before mentioned deflects the solids in suspension towards the bottom of the inverted cone, and the coarser and heavier solids at once find their way through the deposit pipe into the center chamber; the lighter solids, on the other hand, rise to the top of the kessel, while the liquid still carrying a large proportion of fine solids in suspension commences to gradually rise in the kessel, as may be seen by experimenting with the model before you. These finer solids are gradually dropped during the slow upward rise of the sewage in the large cylinder or kessel, and before the level of the outlet connected to the long arm or discharge pipe is reached, practically all the solids in suspension have been left behind, and the effluent leaving by the discharge pipe is quite free therefrom.

The heavier solids on reaching the bottom of the kessel are diverted by the inverted cone-shaped bottom thereof to the central or deposit pipe, and through this into the chamber. This latter may be extended to a size sufficient to hold any desired quantity of solids. It is a curious fact that as this chamber fills with the solids, the liquid portion of the contents passes out through the same pipe by which the solids enter; consequently, this chamber may be worked until the percentage of liquid left is sufficiently small to enable the solid contents to be handled with comparative ease.

The section of the suspended solids which have a less specific gravity than water accumulate on the underside of the dome cover of the kessel, and are easily withdrawn therefrom by opening the discharge pipe for gas and fat, closing the valves in the three siphon legs and turning on the water supply.

The liquid portion freed from solids in suspension passes off through the effluent carrier either to filters or land. The rate of discharge through the effluent carrier is in exact proportion to the flow entering the inlet chamber. With some sewages the treatment by the kessel is sufficient to admit of its being passed direct into a stream.

The author is also of opinion that it is desirable to treat in a similar manner all sewage where it is now discharged in a crude state into the sea, as it is scarcely possible to find any important seaside resort without a sewage outfall far too close to the beach set apart for bathing.

The quantity which can be treated depends upon the size of the kessel used and the nature of the sewage, and will vary from a flow, which will produce an upward motion over the whole sectional area of the kessel or cylinder of ½ to 1 mm. per sec., or put into English measure, 1¼ to 2½ ins. per min.

To give an example of the size required, a kessel with a diameter of 8 ft. would deal with from 2,000 to 4,000 gals. per hour [2,400 to 4,800 U. S. gals.]. A diameter of 30 ft., 25,000 to 50,000 gals. per hour [30,000 to 60,000 U. S. gals.]. The height is, of course, limited by the atmospheric pressure as compared with specific gravity of the liquid dealt with, that is, from 27 to 30 ft. Putting the size of the kessel in terms of the flow to be treated, it should hold from 1½ to 3 hours' flow.

With regard to the results produced by this class of installation, analyses show that with waste from a paper factory, 75 to 90% of suspended matter was eliminated according to the rate of flow, whereas with slaughter-house refuse as much as 99.7 of the solids in suspension and 99.6 of fat is removed.

With an ordinary domestic sewage about 70% of the solids in suspension were removed.

These results compare very favorably with those given in the Royal Commission Report previously referred to. The best examples given of results from treatment by sedimentation tanks show a removal of about 50% of the suspended solids from tanks which hold as much as from 10 to 15 hours' flow.

The second type of separator consists in its essential features of a shallow grit chamber followed by a comparatively small and shallow tank, the capacity of the grit chamber being sufficient to steady the flow of sewage and admit of the grosser and heavier solids sinking and the lighter solids rising. The exit from the grit chamber to the shallow tank following it is kept well below the surface, and the flow passing forward contains only the more finely divided solids in suspension, the specific gravity of 99% of which will be found to be slightly in excess of water in almost all sewages.

In the somewhat larger area of the tank these finer solids sink to the bottom if the outlet from the tank is arranged so as to avoid any movement in the liquid, the velocity of which is sufficient to carry the finely divided solids forward with it. To put it in other or more familiar words, there must be no movement in the tank with what we should call in a sewer a "self-cleansing velocity."

The method by which this is attained in the separator now under consideration is by dividing the flow from the tank over the edges of a large number of small channels placed on the surface, all of which are set truly level the one with the other. The flow is thus divided over what may technically be said to be a very long length of weir. The velocity of the approach to the weir is so low that even the finely divided solids are left behind if their specific gravity is the least in excess of water.

In larger plants the shallow tank is divided into sections for the better regulation of the flow through same. (Fig. 2 shows a separator of this class, capable of dealing with 30,000 gals. [36,000 U. S. gals.] per hour of ordinary sewage.) Both the grit chambers and the shallow tanks are fitted with floors and draw-off pipes especially designed for the easy removal of the solids.

For continuous work this type of separator should be arranged in duplicate like that shown in the view, so that one-half may be cleared of solids while the other is in action; one section should be cleared daily.

FIG. 2. A BRITISH TYPE OF SEWAGE SEDIMENTATION TANK.

The tanks and grit chambers are both fitted with arrangements for drawing off as much as possible of the supernatant water before the solids are withdrawn.

The total capacity of an effective plant of this type may be kept down as low as half an hour's flow of the maximum volume to be dealt with, and such capacity divided into the two sections above referred to.

Some remarkable results have been obtained with a plant of this type at Dorchester, where at least 25% of the total volume of the sewage is brewery refuse. The

*A paper read before the Incorporated Association of Municipal and County Engineers, at a Home District Meeting held at Winchester, England, Oct. 9, 1909.

proportion of suspended solids removed from the crude sewage in this manner is as high as 96.5%, and at the same time the purification effected on the albumenoid ammonia figure is 74%, and on the oxygen consumed figure 89.9%, and that without filtration of any description.

Such results compare very favorably with those produced by many complete installations of tanks and filters. If equally good results can be obtained from a weak or dilute sewage, it appears to me that subsequent filtration or treatment of any kind is entirely superfluous.

Another very considerable advantage, especially in small town installations, is that this type of plant enables the solids or sludge to be dealt with day by day instead of allowing it to accumulate until the volume is so great that to deal with it entails the employment of a considerable amount of extra labor. Taking it day by day a single caretaker at a small town installation can easily do all that is necessary.

It appears to the author that a type of plant which produces such results could certainly be modified to effect the purification of drinking water; at any rate, it would remove the suspended solids which give us so much trouble in the effluents from many sewage filters.

The principle involved in both these types of separators is, that after the water has done its work of transporting the polluting solids from the house to the spot where they can be dealt with, the sooner it is separated from the sewage solids the better. This is especially so in districts such as this where, as a rule, the water supply is from chalk and consequently hard. The amount of dissolved impurities taken up in solution by the water used for conveying the sewage will be very small with a plant of this sort, through which the whole flow passes in less than an hour, compared with a sedimentation or septic tank, the capacity of which varies from 15 to 30 hours' flow.

Another point which strongly appeals to the author is that the manurial value of the solids separated is correspondingly increased, as it has always appeared to him that the septic treatment of sewage has actually destroyed material that could far more usefully be used on the land.

The author is indebted to Mr. Fred. J. Commin,* consulting engineer, 1, Victoria Street, Westminster, for some of the foregoing particulars.

Suggestions for the Standardization of Contracts and Specifications in New York City.

The Board of Estimate of New York City some weeks ago appointed a Committee of Engineers to consider the feasibility of formulating standard specifications for contract work done in the several boroughs of the city. At present this work is under the jurisdiction of the several borough presidents; and as each borough has its own engineering organization, a contractor laying a sewer in Brooklyn may have to work under an entirely different specification from that governing when he lays a sewer in the Bronx.

The move for the standardization of the city specifications originated with the General Contractors' Association of New York City, and that association on Dec. 6, through its Secretary, Mr. C. A. Crane, submitted a brief embodying its suggestions relating to sewer specifications. Many of the matters discussed in this brief are of general interest to contractors and engineers located elsewhere than in New York. We print portions of the brief as follows:

Concerning the Contract.

First—All contracts should contain a clause providing that in the event of payments not being made within the stipulated time, said payments should draw interest at 6% from the expiration of the stipulated time until payment is made.

We feel that this provision will enable the contractor to receive his payments promptly and in the event that he does not he will not be subjected to the loss of interest on borrowed money. It will also operate to the city's advantage in that the delayed payments will not constitute a breach of contract on the city's part.

This provision of interest on delayed payments is not a new one, being at present incorporated in the contracts of the Board of Water Supply, wherein interest is paid at the rate of 4½% per annum. The Administrative Code accompanying the proposed charter for New York provides for the payment of interest at a rate not exceeding 4% per annum if the amount shall be delayed beyond the time stipulated. We feel, however, that the rate of interest should be the legal rate—6%—as is exacted by the city from its debtors, and which would be the rate which contractors would pay when borrowing.

The fact that this provision is contained in the new charter would indicate that it would be permissible in contracts for assessment work, as well as on contracts payable from other sources.

Second—When a contract for a public improvement, whether payable from the Street Improvement Fund or other funds, exceeds in amount $300,000, the per cent. retained on partial payments should not be exacted after the retained amount reaches the sum of $75,000. The charter provides that in assessment work 30% shall be retained, but why that percentage should be required on assessment work and not on work payable from other sources is not apparent to us. This large retention adds materially to the cost of the work without equivalent return to the City. We would therefore ask that the percentage should not be required beyond the time when the sum amounts to $75,000 and that payments in full should be made for all work done after that sum is reached until the completion of the work, or the additional retention be at a reduced rate, for the reason that with this retained money, in addition to the bond for performance of the contract, the city is amply secured for the faithful performance of the contract.

Third—We would ask that your committee recommend to the Board of Estimate and Apportionment legislation which would require that a claimant for damages suffered by reason of a contract for public work should file a bond equal in amount to the bond required from the contractor by the city, in order to release his payments. The justice of this request must be apparent to all who are familiar with public contracts, which seem to be a target for fraudulent claimants. Instances are not uncommon where suit has eventually been brought for a sum which is but a small percentage of the amount originally mentioned in the claim. The requirement that the claimant should file a bond would be a two-fold benefit in that it would accelerate the suit in the case of a bona fide claim and would discourage claims without substantial cause.

Fourth—We submit that the provision in the contract requiring that the bid shall be accompanied by the consent of two freeholders or householders as sureties is unnecessary and affords no protection to the city and therefore should be abolished. The charter provides that all bids shall be accompanied by a certified check or cash in 5% of the amount of security for the contract. It would therefore require legislation to effect a change; but we would suggest that in contracts on which the security required is $250,000 or less the certified check or money to accompany the bid be in 10% of the security, and further that the certified checks or money of the unsuccessful bidders be returned within three days after the opening of bids.

The charter provides that the contract shall be awarded to the lowest formal bidder or all bids shall be rejected, except the Board of Estimate and Apportionment by a three-fourths vote may accept a bid other than the lowest if deemed for the public interest so to do, and as this bidder as well as the lowest bidder is readily ascertained in three days after the opening of bids we feel that there is no necessity for retaining the checks for a longer period.

Fifth—We ask that your committee recommend action tending to the discontinuance of the practice adopted by Finance Department Engineers in arbitrarily readjusting prices of work performed under agreement with a city department. We feel that this is one of the gravest abuses in contract matters, and as unjust as it is unlawful. The contract provides that the decision of the Engineer-in-Charge shall be binding on the contractor, but not upon the city, and we find many instances of payments having been reduced, not because of alleged fraud on the part of the contractor or engineer, but to meet the cost basis assumed by the Finance Department Engineer contrary to the price decided and agreed upon by the Engineer-in-Charge and the contractor who are best qualified by knowledge of conditions to judge of the work, and ratified by the Corporation Counsel. We maintain it is not within the province of the Finance Department to criticize prices which have been established by the contract, and the only question to be determined is on the performance of the work. Any refusal on the part of the examiner to certify the final bills for payment on the ground that the prices are excessive, we submit, is unfair and illegal, and imposes upon the contractor the alternative of litigation to obtain what the city has already agreed to give him or of accepting the reduction because of the delay and cost attending a suit, the winning of which might cost more than the amount in dispute.

We ask the good offices of your committee tending toward relief from this practice, as we feel that what is expressly admitted to be unfair should not be permitted to continue.

Sixth—The contract provision that the decision of the Chief Engineer shall be final and binding in settlement of disputes, interpretation of the specifications and the measurements of quantities has been the subject for endless discussion and much litigation.

Quotations are then made from the late Prof. J. B. Johnson's "Engineering Contracts and Specifications," p. 86, and from Waddell and Wait on "Specifications and Contracts," Sec. 50, p. 162. The recommendation m... is that a clause should be inserted in each ...tract permitting either party to appeal f... the Chief Engineer's decision to a single ar...tor, who should be some distinguished high... engineer free of bias and familiar with the ... of work in question.

Seventh—We submit that in the event ... city connecting existing sewers, or permitting ...nections of drains with a sewer under construction, ... contractor should not be required to maintain any pa... of the sewer in which the connection shall flow and ... such connection or permission to connect constitu... an acceptance by the city of that portion of the se... so utilized, and the contractor should be paid in ... for such portion.

Specifications:

First—Rock excavation should be paid ...or at the maximum area of section prescribed, whether maximum section be removed or not. A precedent existing in the contracts of the Board of Water Supply for the Catskill Aqueduct admits the justice of this request, as it would permit a contractor to average up on his trench excavation in localities where it were possible to excavate within the maximum lines as opposed to those portions of the work where the character of the rock required excavation beyond the maximum lines, for which excess he would not be paid. We would suggest that the maximum section in rock excavation be that as provided in the specification now existing in the Borough of The Bronx for sewers in unpaved streets, and that the section of trench for rock excavation in paved streets shall have vertical sides and be one foot wider on each side than the greatest external width of the sewer; but in no case shall the width be less than 4 ft. 6 ins.

Second—We would ask that the proposal for sewers in all boroughs state an item price for manholes and spurs. This is in keeping with the idea that the itemized bid is preferable to a lump sum bid and is in accordance with the practice in most of the boroughs under their present specifications.

Third—We would ask the elimination of a clause which forbids payment for rock excavation on work where no price for rock is asked and which states that should rock be encountered it must be included in the price bid per foot of sewer. Instead of this clause we would suggest that in proposals for sewer work for which the engineer's estimate does not contain an item for rock, a stated price be named in the contract, to be paid the contractor in the event of rock being encountered. This stated price being fixed at a reasonable sum per cubic yard would forego the possibility of the final amount of the contract being increased excessively over the preliminary figure.

Fourth—We would suggest that the proposal contain an item for restoring pavements. This is already done in contracts for laying water mains and would seem entirely feasible in sewer work as well, for the same reason heretofore advanced, that itemized bidding is preferable to lump sum bidding. It is understood, of course, that where pavement is under guarantee the repaving shall be done by the contractor who laid the pavement and at his prices for the original contract.

Fifth—We would suggest that a uniform and standard specification be adopted in all boroughs for materials used in the construction of sewers and that the form of construction and the materials for same shall be distinctly specified and that the use of alternative material shall not be within the discretion of the engineer in charge. We ask that the recognized standard specification for timber, brick, vitrified pipe, concrete pipe, broken stone, gravel and cement be adopted for use in all boroughs. We ask that the test for cement shall follow the tests prescribed by the American Society of Civil Engineers.

Sixth—We would ask that in contracts requiring a large amount of concrete construction the proposal contain an item for cement. This is in keeping with the practice now followed in some departments to pay for material delivered; and we feel that such a provision would benefit both parties to the contract in that it would insure the specified amount of cement in the work and would remove a temptation to put in a less quantity than required in the specifications.

Seventh—We would ask that the percentage system of bidding on work be abolished for the following reasons:

It does not insure an unbalanced bid unless it could be assumed that the estimate of quantities as made up by the engineer, together with his estimated cost, were absolute and accurate. We feel that a contractor of experience is better enabled to estimate the cost of work than the engineer, whose ideas of cost must be largely a matter of conjecture. It would permit of irregularity in unbalancing the estimated quantities by the engineer preparing the estimate (should he be unscrupulous) and enable him to work in collusion with a favored bidder. By the ordinary system of bidding item by item it is possible, where such a condition of unbalanced quantities exists, to so arrange the prices on the various items—reducing that on an overbalanced item and increasing the price on some other item which will cover it in ac-

[*Formerly associated with Messrs. Donald Cameron and Alfred J. Martin in promoting the septic tank.—Ed.]

dance with the original quantities—as to reimburse bidder for the loss which he will sustain on the erbalanced item. With the percentage system, however, the bidder has no opportunity along that line, as average percentage price is applied uniformly to the gineer's 100% standard, and if that standard too low or too high in any particular item or items bidder has no recourse but to follow the ratio designated by the engineer and must make his percentage sufficiently high to safeguard himself, which course makes bid higher than it would be were the quantities properly stated by the engineer. It is claimed that the centage system of bidding prevents unbalancing by contractor; but it would seem possible for the gineer to detect an unbalanced bid quite as readily by system of item bidding, as he could apply his uniform standard in comparison with the contractor's scale of prices and satisfy himself whether the latter were unbalanced. The fact that the engineer has established the 100% basis for bidding might be assumed by the uninformed that such standard was sufficient and that prices should never exceed the engineer's limit. We submit that the engineer is not in a position to make the careful estimate of cost that the contractor must make in submitting his bid for the work. The engineer is apt to assume that certain fixed standards will meet all conditions, which is not true in all cases, and may result in an unbalanced estimate as the standard. The contractor in estimating a piece of work would figure it item by item and compare his total cost with the engineer's 100% allowance regardless of the fact that his scale of cost may not correspond in ratio in every respect with those given by the engineer. It is impossible, therefore, to tell whether on the completion of the work the quantities will have been justified and as a matter of prudence he will be inclined to increase his figures to cover this contingency.

Notes from Engineering Schools.

COLLEGE OF THE CITY OF NEW YORK.—The department of chemistry has offered a course for the spring semester in "the chemistry of daily life." In addition to 30 popular lectures there will be offered a laboratory course on the examination of water, milk, foods, gas, paints, cements, etc.

The complete course is open to senior students of the college and to qualified city employees. Also a limited number of citizens will be permitted to attend the lectures, all of which are scheduled to be given at 4 p. m. The lecture topics include sanitation, water supply, milk, foods, drugs, streets and roads, wastes disposal, gas, ventilation, personal hygiene, paints, fires, and city parks, to be presented in the order named.

CORNELL UNIVERSITY.—The recent annual report of President Schurman contains the following reference to the new dormitory built by the Telluride Power Co.:

It appears that a number of students have been sent to the University by the Telluride Power Co., a corporation which owns and operates a number of power plants in Colorado and Utah. The head of that business, Mr. L. L. Nunn, visited the University in June and explained to the President that he desired to erect on or near the campus a building to be used as a home by these young men. Mr. Nunn is greatly interested in scientific research, of which a beginning may be made in connection with the new residential hall. Meanwhile a group of University students, undergraduate or graduate, selected by him will have the advantage of living together in this new and beautiful home. This makes better provision for the life of the young men than could be offered by the University, which, on the other hand, has no responsibility for the enterprise. It appeals, however, very deeply to the sympathy and interest of the President, Trustees and the friends of the University. Mr. Nunn's generosity may prove an inspiration to other wealthy men and the house he is building on the campus may possibly serve as a model for the type of small student halls at Cornell. It will certainly furnish an opportunity of testing the advantages which have been claimed for the type of small residential halls, particularly when occupied by older students, graduates or upperclassmen.

The building will accommodate about forty students. It is of fire-clay brick, four stories in height, with a frontage of 106 ft. and a depth of 48 ft. It is of fireproof construction throughout, all partitions on a steel frame. The two upper floors are divided into suites of two rooms and a bath. The rooms are all large, none being less than 12 x 18 ft. The second or main floor contains the library, hall, and general living rooms. The ground floor is provided with a dining room, breakfast room, billiard hall, kitchen and culinary room, including an engine room and laboratory. It is well equipped with a forced ventilating system of sufficient capacity to change the air throughout the entire building every ten minutes. This system is so installed that the air may be heated or cooled to any desired temperature. An ammonia refrigerating system will be installed, which, together with a vacuum cleaning system, an isolated power plant, and the ventilating system, will make an ideal equipment.

UNIVERSITY OF WISCONSIN.—A recent bulletin announces that the University Extension Division maintains a Municipal Reference Bureau which collects information on the varied subjects of municipal activity and municipal government for the purpose of rendering that material accessible to the cities and citizens of the state. The Bureau is in charge of a specialist in municipal administration, and has the co-operation and assistance of the Political Science department of the university and the legislative reference department of the Wisconsin Free Library Commission. All assistance is rendered free of charge. The bulletin sets forth the object of the Bureau as follows:

Municipal reference departments have been established in many of our large cities. But every city cannot maintain such a department. The Municipal Reference Bureau aims to perform this service for the cities of Wisconsin. So far as time and resources permit, it aims to collect and furnish information on all subjects of municipal organization and administration, public works, public utilities and public service rates, municipal employment, paving, sewage disposal, water supplies and water purification, garbage disposal, parks and play-grounds, housing, street cleaning, street sprinkling, dust prevention, smoke abatement, city planning, civic centers, art commissions, care of city trees, schools, charities and corrections, health and sanitation, accounting methods, comparative statistics, commission government, home rule, civic organizations, and all the other subjects of municipal interest, and so far as possible, to collect and maintain a file of charters and ordinances of the principal cities of the United States, and the available municipal material of the principal cities of Europe and the continent.

It has correspondents in most of the principal American cities, and in this way is able to furnish information as to what cities have (for instance) a milk ordinance, a wheel tax or other ordinance, how they work, and if desired lend a copy of the ordinance. It can tell how boards of public works are organized in various cities, how school boards are constituted, or how street sprinkling or street repairs are paid for. In short, it aims to be a clearing house for municipal experiments and experience.

Two fellowships in engineering, worth $400 a year each, have been established by the regents of the University. There were previously three graduate scholarships in the college of engineering. These remain and, with the fellowships, are to encourage engineering research. There are at present 30 graduate students in the University doing much advanced work, in reinforced concrete, hydraulics, electro-chemistry and chemical technology.

THE BURSTING OF AN OXYGEN TANK in use in connection with an oxy-acetylene welding outfit wrecked an automobile garage at Columbus, Ind., Dec. 20.

AN EXPLOSION IN A COAL MINE at Herrin, Ill., Dec. 23, killed eight men. An extensive fire followed the explosion. The accident is ascribed to the ignition of gas by open lamps. The mine is owned by the Chicago & Cartersville Coal Co. and is known as Mine A.

A TROLLEY CAR PLUNGED INTO A RIVER near Seymour, Conn., Dec. 26. This was the first car to attempt the trip over the lines of the Connecticut Ry. Co. from Waterbury to Derby, Conn., after the snow storm of Dec. 25. It was derailed at a switch and ran down a 10-ft. embankment into the Naugatuck River. The car entered the river head first, breaking through the ice, and remained standing on end on the river bed. The motorman and conductor were both in the forward vestibule and were drowned, but none of the six passengers was seriously hurt.

A BUTTING COLLISION between two freight trains took place near Fort Ritner, Ind., on the Baltimore & Ohio Southwestern R. R. Dec. 27. Five trainmen were killed. The trains met on a sharp curve and the accident is ascribed to a misunderstanding of orders.

A RAILWAY ACCIDENT IN AUSTRIA Dec. 25 killed ten persons and injured seriously 28 others. An express train bound for Vienna collided with a freight at Uhersko station, near Chotzen, Bohemia.

A LOCOMOTIVE BOILER EXPLODED in the repair shop of the Chicago, Rock Island & Pacific Ry. at Shawnee, Okla., Dec. 24. Three workmen are reported killed and 17 others were injured. The repair shop building was wrecked.

A CAR LOAD OF NITROGLYCERIN EXPLODED Dec. 23 at La Motte, Mo., in the plant of the E. I. Dupont de Nemours Powder Co. One man was killed by the explosion and several buildings were destroyed by the fire which followed. Reports state that 35 5-gal. cans of nitroglycerin exploded.

THE U. S. COLLIER "NERO" WAS RAISED from Brenton's Reef with compressed air by the Arbuckle wrecking company and was towed to the Brooklyn Navy Yard, arriving late in the evening of Dec. 22. The trip of about 150 miles from Newport, R. I., to the navy yard in Brooklyn, was made in about 40 hours through a heavy sea. During this trip, the vessel was kept afloat only by the air compressors of the Arbuckle system, which kept her hold full of compressed air, for the large openings in her bottom, sustained when she went aground on the reef, had not been repaired. She was ballasted with 150 tons of coal and a quantity of sand in barrels for convenience in trimming ship.

The "Nero" is a steel vessel 320 ft. long, over all, with a displacement of 6,360 tons. She went aground on Brenton's Reef, July 1, 1909. After ordinary means had failed to move her from the reef, the Arbuckle company began work and succeeded in floating the vessel off the rocks and she was towed into Newport on Aug. 3.

A BOILER EXPLOSION at New Philadelphia, Ohio, Dec. 17, in the plant of the Robison Clay Product Co. wrecked the boiler and engine room. Two men were killed and seven others injured.

A RUNAWAY FREIGHT WRECKED THE UNION Station at St. Paul, Minn., Dec. 25. The train of eleven cars had just been made up in the Como yards when it was found that the air brakes could not be operated. There is a continuous down grade from Como to the Union Station and by the time the station was reached the train had attained a speed of more than 60 mi. per hr. The locomotive crashed through the two brick walls of the baggage room and fell through into the basement. The train crew escaped by jumping.

A BIG AVIATION MEET is planned at Los Angeles, Cal., from Jan. 10, 1910, on. The meet will be like the recent one at Rheims, France, and will be held under the approval of the Aero Club of America and the International Aeronautic Federation. According to the reported announcements of the promoters, $80,000 has been subscribed for prizes.

It is planned to offer 13 prizes for spherical balloons, ranging from $10 to $10,000, the grand prize of $10,000 being for the balloon that will travel from Los Angeles to the Atlantic coast.

There are 15 prizes, ranging from $50 to $5,000, for aeroplanes. The $5,000 is for the aeroplane that breaks all the world's records. A prize of $1,000 is for the machine of any type that will soar without engine power for twenty minutes.

Seven prizes, ranging from $250 to $10,000, are offered for dirigible balloons. The grand prize of $10,000 is for the airship that will sail from Los Angeles to San Francisco, a distance of 600 miles.

THE BURR TRUSS BRIDGE OVER THE HUDSON at Troy, N. Y., which was destroyed by fire in July, 1909, has been replaced by a steel truss bridge. The new structure was opened to traffic on Dec. 18 with a formal initiation, public officials being taken across in the first electric car.

THE U. S. BATTLESHIP "UTAH," the largest warship so far built in the United States, was launched at Camden, N. J., on Dec. 23. The "Utah" is the fifth to be launched of the all-big-gun ships of the United States Navy, and the most powerful of any as yet launched, although there are two ships in the new program which will surpass her. She has a length on the load water line of 510 ft., or 521½ ft. over all, and a beam of 88 ft. 2 ins. Her trial draft will be 28½ ft.; displacement, 21,285 tons, and her speed is expected to be 20¾ knots.

There will be ten 12-in. breech-loading guns in her main armament mounted in five turrets on the central line of the ship. Two of the turrets will be forward, one amidships, and two aft. Each turret will be protected by armor 8 and 12 ins. thick. Sixteen 5-in. guns, protected by armor of medium thickness, will be provided for defense against torpedo-boat attacks. She will be fitted with two submerged topedo tubes, and will have ten small guns for boat service and saluting purposes. The main armor belt will be about 8 ft. wide, with an average thickness of 10 ins. Above this will be another belt of an average thickness of 9 ins., and still higher will be the casement armor, protecting the secondary battery and funnel bases. Each barbette will be made of armor varying from 4 to 10 ins. in thickness, and will protect the entire ammunition-handling machinery for the 12-in. guns in the turrets above.

Ten turbines, six for ahead and four for astern, ca-

pable of developing 28,000 HP., will be installed. Steam will be supplied by 12 water-tube boilers, and coal or oil may be used for fuel.

FRICTION COEFFICIENTS FOR BRAKE BLOCKS.—In London "Electrician" of Dec. 3, an article by Prof. Ernest Wilson, of Kings College, London, W. C., is abstracted from an official circular of the Tramways & Light Railways Association. Tests for determining the coefficients of friction of various brake shoes are noted and tables of coefficients are given. In the case of a chilled-tire tramway wheel, clean water being used for lubrication, the coefficient for oak varied from 0.037 to 0.073 as the load increased from 40 lbs. to 120 lbs. per sq. in., the speed being maintained at 7 mi. per hr. At 15 mi. per hr. the corresponding values were 0.032 and 0.055. For poplar the values for the same two speeds were 0.041 and 0.038 at 40 lbs. per sq. in. loading and 0.070 and 0.053 at 100 lbs. per sq. in. For Frood's lining (black) the coefficients obtained at 7 and 15 miles per hour were 0.034 and 0.026 at 40 lbs. per sq. in. loading, and 0.055 and 0.045 at 100 lbs. per sq. in.; while plain grey cast iron showed values of 0.32 and 0.28 at 20 lbs. per sq. in. and 0.30 and 0.26 at 80 lbs. per sq. in. The speeds again being 7 and 15 mi. per hr. respectively. The tests when no lubrication was used at the above-mentioned speeds showed values: for oak, of 0.60 and 0.55 at 10 lbs. per sq. in. loading, and 0.43 and 0.40 at 40 lbs.; for Frood's lining, of 0.70 and 0.63 at 10 lbs. and 0.50 and 0.48 respectively at 40 lbs. loading; whilst for cast iron the values were 0.43 and 0.37 at 10 lbs. and 0.36 and 0.30 at 40 lbs. For poplar, the values at 15 mi. per hr. were 0.72 at 10 lbs. loading and 0.53 at 40 lbs. per sq. in. Once or twice with water lubrication, combined with low temperature, the motors raced with a load of 120 lbs. per sq. in. in the case of non-metallic linings, and there were misgivings as to their reliability for tramway purposes. During these tests the driving wheel on each axle furthest from the spur wheel became corrugated, the number of corrugations corresponding with the number of teeth on the spur wheel. This effect is attributed to the spring in the shaft combined with imperfect gearing, and was believed to be related to rail corrugation on tramways.

BUILDING WALLS OF MESH-REINFORCED CLAY is advocated by W. Paetz, of Harburg, Germany. He has worked out a complete practical system of construction on this basis, and described it in a pamphlet ("Lehmdrahtwände, die billigste Bauweise der Gegenwart," published by the author). He tells of the erection of two buildings on this system in the "Zentralblatt der Bauverwaltung" of Nov. 17, 1909. The reinforcement comprises inner and outer sheets of wire fabric, and horizontal bedding sheets whose vertical spacing should not exceed the thickness of the wall. The preferred arrangement is to use sheets wide enough to form the two bedding sheets and also the outer faces of such a block of wall, and bend them into a hollow rectangle. In case of walls for heavy loads, a layer of cement mortar is placed between successive courses of wall. Window openings, etc., are framed in cement mortar, placed so as to dovetail with the courses of clay work. Wall plates, floors, roof framing and partition framing are of timber studding, but partitions are preferably filled with clay tamped between sheets of metal fabric nailed on each side of the studding. The exterior wall surfaces are covered with a coating of neat cement mortar as soon as finished, and the outside of this coating may be further plastered or dressed as desired. The inside wall surfaces are not plastered until after the walls have dried out fairly well; they are coated with plaster on neat cement mortar. The clay to be used in the wall construction should be used fairly dry, i. e., just moist enough to be capable of being tamped into a solid mass. It is said that it will usually be necessary to stack freshly excavated clay for a few days, under cover, to let it drain and dry out sufficiently. The government last year built a two-family dwelling of this system near Munster, and after its completion a stable of the same construction was built on the premises. The total cost of both buildings is given as $2,000.

QUEER IDEAS AS TO PURITY OF WATER.—A City Council in Oklahoma advertised that the city's spring water was 98% pure. This would be 20,000 parts of impurity per million. Another city went into the papers with the bold statement that its purifying system was furnishing water that was 98½% pure. Think of it. Only 15,000 parts impure per million. The ridiculousness of these boasts may be illustrated by reference to the Steelton (Pa.) water-works. The water there is so filthy that they filter it through coal slack before allowing it to go to the sand filters and yet its maximum turbidity is only 1,600 parts per million. Our city officials in Oklahoma were simply boasting that their water was not more than 9 to 13 times as bad as the very bad water at Steelton. They may learn some day that water that is not at least 99.99% pure is nothing to brag about.—From address by H. V. Hinckley, Retiring President of the Oklahoma Engineering Society, at the Society's Annual Meeting.

Personals.

Mr. R. H. Baker has resigned his position as President of the Trinity & Brazos Valley Ry.

Mr. Robert Laidlaw has been appointed Superintendent of Water-Works of Cincinnati, Ohio.

Mr. Emil de Neuf, Assistant City Architect of San Francisco, Cal., has been made City Architect in place of Mr. Loring P. Rixford.

Mr. E. F. Schneider, Secretary of the Cleveland Southwestern & Columbus Ry., at Cleveland, Ohio, for the past ten years, has been made General Manager to succeed Mr. C. N. Wilcoxson, resigned.

Mr. F. H. Lincoln has resigned his position as Assistant General Manager of the Philadelphia Rapid Transit Co. to take a position with the Goldschmidt-Thermit Co., New York City. Mr. Lincoln will be succeeded by Mr. Henry Branson under the title of Superintendent of Rolling Stock and Equipment.

Mr. Walter Loring Webb, M. Am. Soc. C. E., has become associated with the Roberts & Abbott Co., Incorporated, consulting, supervising and operating engineers of Cleveland, Ohio, and will represent that company in Philadelphia and vicinity. His address will be 1026 Real Estate Trust Bldg., Philadelphia, Pa. Mr. Webb is a graduate of Cornell University, class of 1884.

Mr. Harry C. Hill, Assistant State Engineer of New Hampshire, has been appointed State Engineer to succeed Mr. Arthur W. Dean, who has become Chief Engineer of the Massachusetts Highway Commission, as noted in our last week's issue. Mr. Hill is a graduate of the Thayer School of Engineering, Dartmouth College, class of 1903. He formerly served as a transitman and assistant engineer for the New York Central & Hudson River R. R., near Corning, N. Y., and at New York City.

Obituary.

Frank J. Short, at one time in charge of engineering research at Cornell University, died Dec. 22 at Fort Collins, Colo., from tuberculosis. Mr. Short was a graduate of the University of Wisconsin in the class of 1897.

Richard Eames, M. Am. Inst. M. E., was killed Dec. 15 in the accident on the Southern Ry. at Reedy Fork, N. C. Mr. Eames was born in New York in 1858. He was trained as a mining engineer by his father, Dr. R. M. Eames, and had a wide experience in exploration and in the examination and management of mines in North Carolina, Colorado, Nevada, California, Arizona, Rhode Island and New Hampshire, and in Mexico, Honduras and British India. He had made his home in Salisbury, N. C., since 1879.

Engineering Societies.

COMING MEETINGS.

MONTANA SOCIETY OF ENGINEERS.
Jan. 6-8. Annual meeting at Butte, Mont. Secy., Clinton H. Moore, Butte, Mont.

MICHIGAN ENGINEERING SOCIETY.
Jan. 12-14. Annual meeting at Lansing, Mich. Secy., Alba L. Holmes, 574 Wealthy Ave., Grand Rapids, Mich.

INDIANA ENGINEERING SOCIETY.
Jan. 13-15. Annual convention at Indianapolis, Ind. Secy., Chas. Brossmann, Union Trust Bldg., Indianapolis, Ind.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 18-20. Annual meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 19-20. Annual meeting at New York City. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF INSPECTORS OF PLUMBING AND SANITARY ENGINEERS.
Jan. 20-22. Annual convention at Trenton, N. J. Secy., C. S. McCosker, Mobile, Ala.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 25-27. Annual meeting at Ottawa, Ont. Secy., C. H. McLeod, 413 Dorchester St. West, Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting at Cairo, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 7-12. Annual convention at Pittsburg, Pa. Secy., T. A. Randall, Indianapolis, Ind.

CONNECTICUT SOCIETY OF CIVIL ENGINEERS.
Feb. 8. Annual meeting at New Haven, Conn. Secy., J. Frederick Jackson, Box 1304, New Haven, Conn.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 16. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, E. Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 16-17. Annual convention at Cedar Rapids, Iowa. Secy., A. H. Ford, Iowa City, Iowa.

NATIONAL ASSOCIATION OF CEMENT USERS.
Feb. 21-26. Annual convention at Chicago, Ill. Pres., Richard L. Humphrey, Harrison Bldg., Philadelphia, Pa.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Feb. 24-26. Annual meeting at Chicago, Ill. Secy., D. J. Hauer, 721 Park Row Bldg., New York City.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—At the meeting in Montreal, Que., Dec. 16, Mr. A. D. Swan, Resident Engineer of Montreal Harbor, presented an illustrated paper describing the construction of the new harbor, wet dock and graving dock at Bristol, England.

WOOD PRESERVERS' ASSOCIATION.—The annual meeting will be held at Chicago, Ill., Jan. 18. The president is Mr. Walter Buehler, 508 Pierce Bldg., St. Louis, Mo.

WESTERN RAILWAY CLUB.—At the regular monthly meeting in Chicago, Ill., Dec. 21, Mr. W. U. Turner, of the Westinghouse Airbrake Co., presented a paper on "Brake Manipulation in General Freight Service," in which he reviewed some of the causes and conditions which produce shocks and break-in-twos.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.—In accordance with the resolution adopted at the convention in Denver, Colo., Oct. 18-22, a general conference will be held Jan. 28 in New York City. This conference will be open only to the officials or representatives of member companies who fix the policies of the member companies they represent.

INDIANA ENGINEERING SOCIETY.—The preliminary program for the annual meeting at Indianapolis, Jan. 13-15, has been given out as follows: Presidential Address, E. E. Watts; "Stream Pollution," (three papers), Chas. C. Brown, R. L. Sackett, H. C. Jordan; "Arches; An Historic Sketch," M. A. Howe; "Some Types of Reinforced-Concrete Construction," E. E. Watts; "Preparation of Plans for Steel Highway Bridges," B. B. Johnson; "The Ohio River Sanitary Commission," J. N. Hurdy; "The Work of the Indiana Railroad Commission," W. J. Wood; "The Deep Well System of South Bend, Ind.," A. J. Hammond; "A Sewer Franchise," J. W. Fulwider. Papers of which the titles have not yet been announced will be presented by W. K. Hatt, Chas. Brossman and C. L. Olds. In connection with the convention, various manufacturers have prepared exhibits of engineering materials.

WESTERN SOCIETY OF ENGINEERS.—The society is having an exceptionally active season, and at several of its recent meetings papers of more than ordinary interest have been presented. As an offset to the technical meetings also, a "ladies' meeting" was held Dec. 10, at which a musical entertainment was furnished.

In view of the important movement looking to the improvement of the harbor and the harbor facilities of Chicago, and as the outcome of a paper on "The Chicago Harbor" read by Mr. John M. Ewen, a committee has been appointed for the special purpose of representing the society at the several public hearings and of keeping the society informed as to the proceedings and developments. Mr. A. Bement is chairman of this commission.

The society has for some time had an Electrical Section, with its own officers and holding meetings independently of the society's regular meetings. A Bridge and Structural Section has recently been organized on similar lines, and has already about 100 members (who are members also of the society). Mr. T. L. Condron was elected Chairman and Mr. W. C. Armstrong, Vice-Chairman. At the first meeting of the section a description of "The Eight-Track Bascule Bridge Over the Chicago Drainage Canal" was given by Mr. C. R. Dart, Bridge Engineer, and Mr. S. T. Smetters, Assistant Bridge Engineer, of the Chicago Sanitary District.

At the regular meeting of the society on Dec. 1, a paper on "Mine Accident Investigations of the U. S. Geological Survey" was presented by Mr. Geo. S. Rice, Mining Engineer of the Survey. This was of particular interest in view of the recent disaster at Cherry, Ill. It was supplemented by an address from Mr. R. Y. Williams, Mining Engineer in charge of the U. S. Geological Survey's rescue station at Urbana, Ill. He described the explorations made in the St. Paul mine (at Cherry) after the accident, and exhibited the special helmet and oxygen apparatus used in enabling the rescuers to traverse the gas-filled mines in life-saving work. Some remarks on similar lines were made also by Mr. H. H. Stoek, head of the newly organized Department of Mining Engineering at the University of Illinois.

At the meeting on Dec. 15, a paper on "A Unique Type of Reinforced-Concrete Building Construction" was read by Mr. T. L. Condron. The system referred to consisted of a self-supporting slab floor, without beams or girders. The floor is designed as a continuous structure over the area of the building, provision being made for stairway and elevator openings. Between the columns the depth is increased slightly, giving the appearance of a paneled ceiling, the width of the deeper part being greater than the width of the columns. In this building the columns are spaced 24 ft. apart in both directions. This system requires less depth of floor, gives better facilities for lighting, and involves a much simpler and cheaper form of construction than the girder, beam and slab type of floor. It is the invention of Mr. Sinks, of the firm of Condron & Sinks, consulting engineers.

The steel work in the columns of this building consist of four tee-bars, connected by batten plates. In other buildings referred to in the paper, the columns have interior structural steel columns of the box lattice type, with four angles laced on all sides. Other special features described were steel I-beams in the concrete beams, and slab roofs of large span supported by steel roof trusses encased in concrete. This last system has been employed in the new car houses for the Chicago street railways.